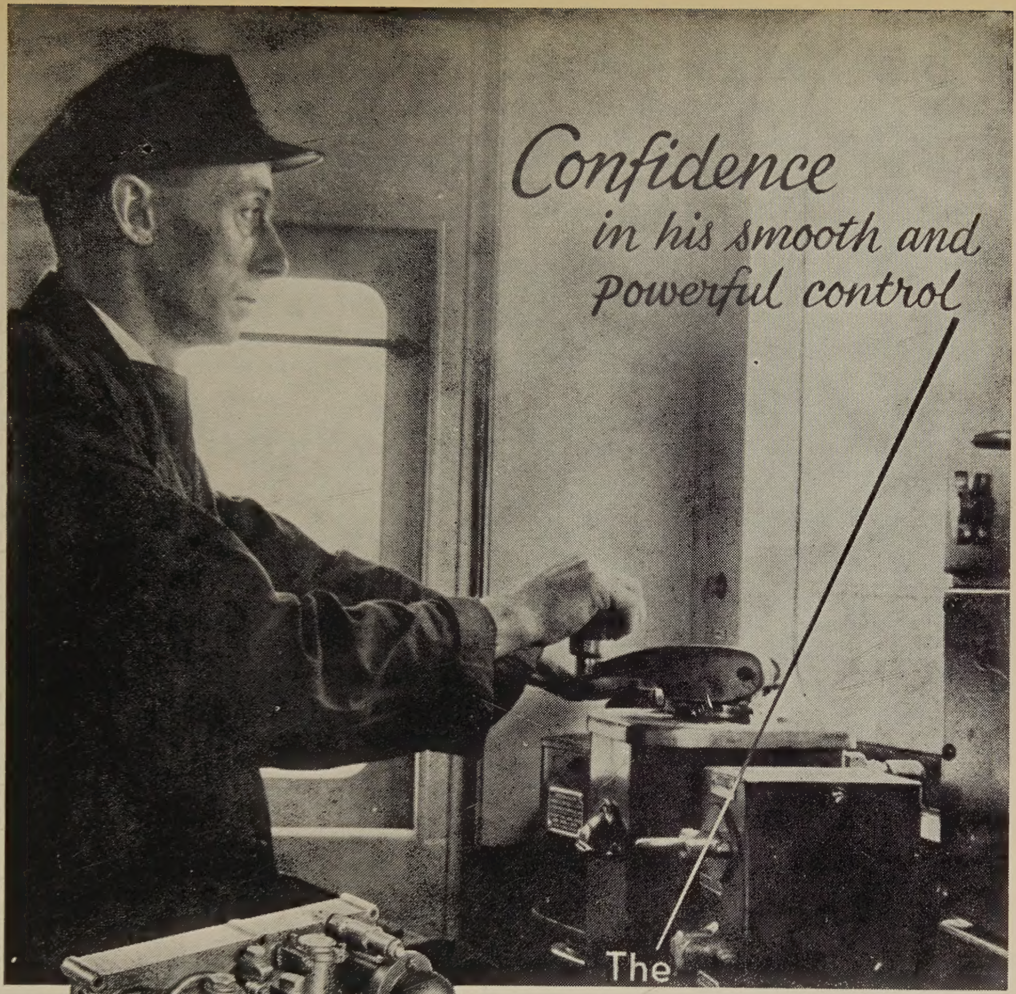
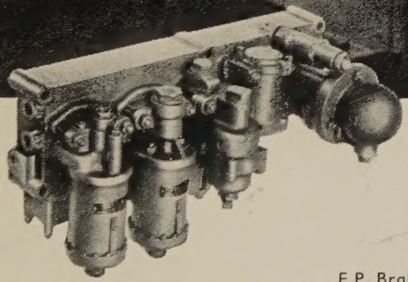
VOL. XXXII. — No. 9. SEPTEMBER 1955.

Monthly Bulletin of the International Railway Congress Association

(English Edition)





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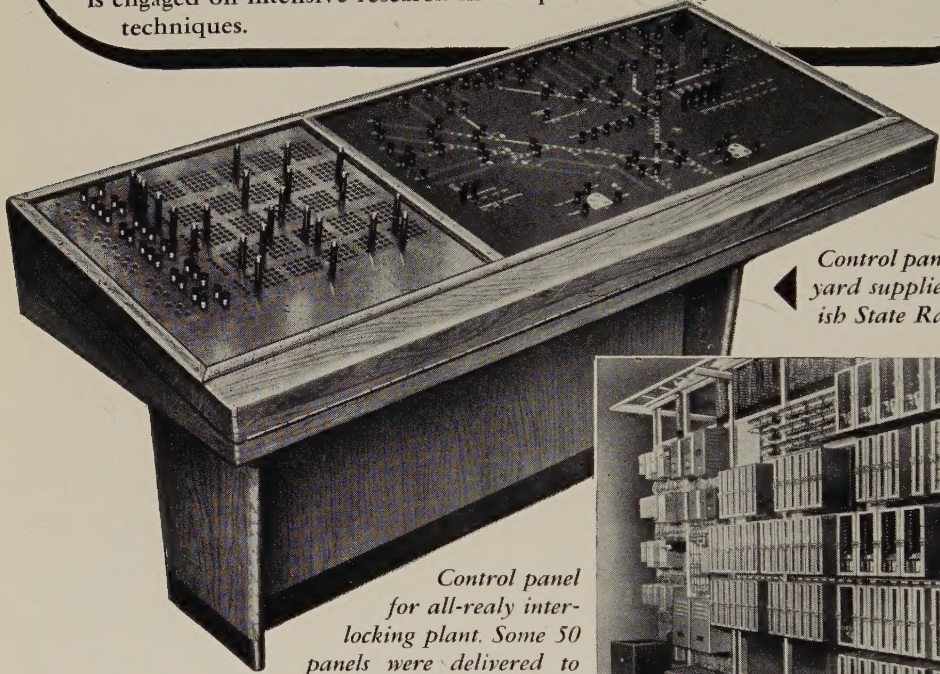
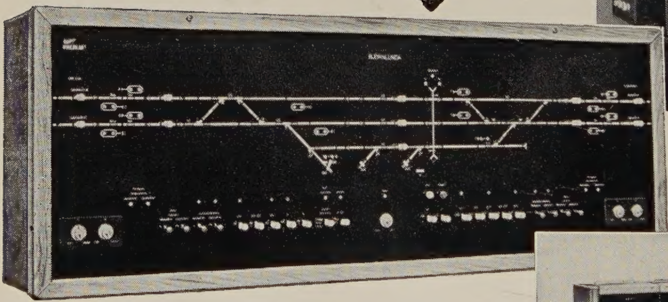


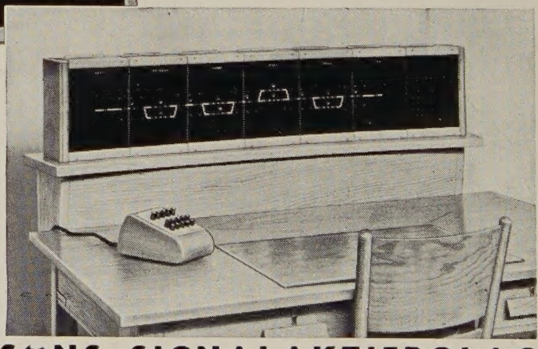
Control panel for bump yard supplied to Swedish State Railways.

Plug in relays assembled in racks.

Control panel for all-realy interlocking plant. Some 50 panels were delivered to Swedish State Railways in 1954.



Track diagram and dispatcher's key set for C.T.C.



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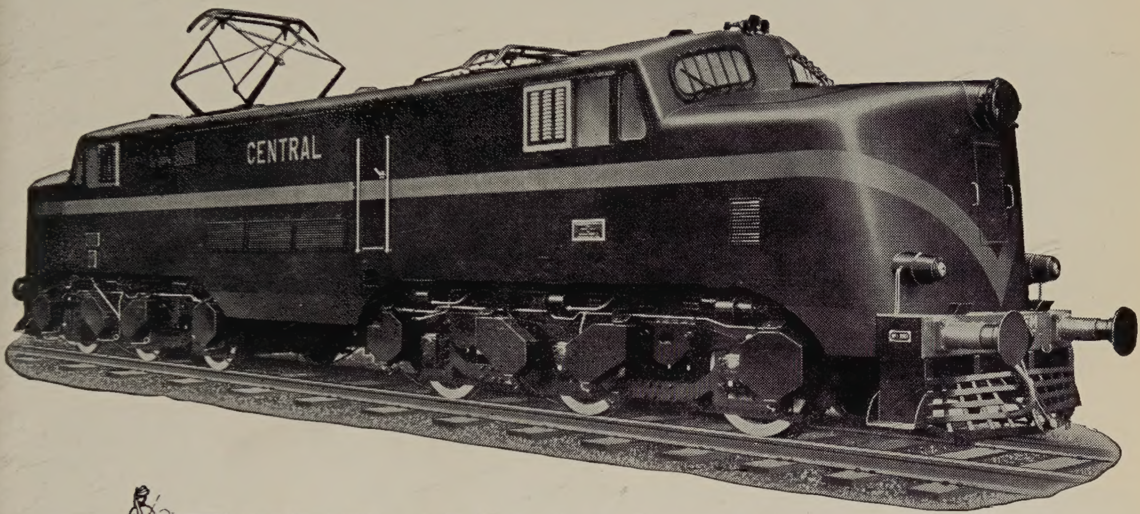

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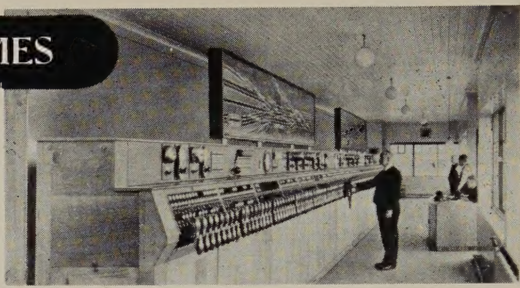

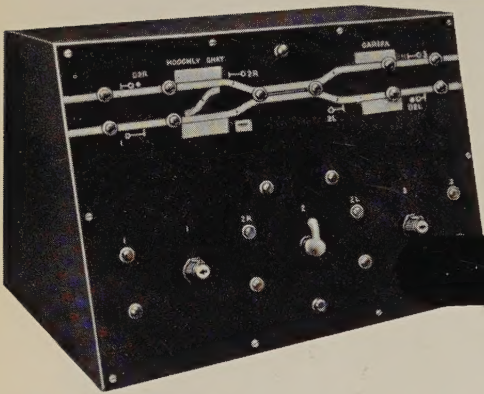

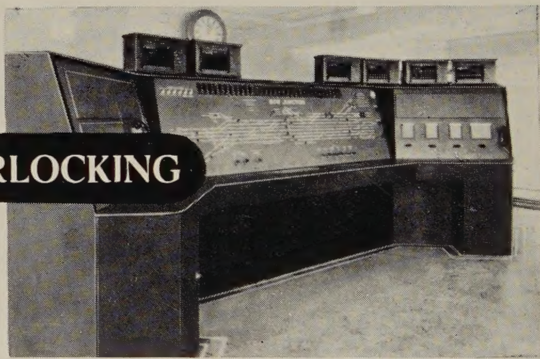

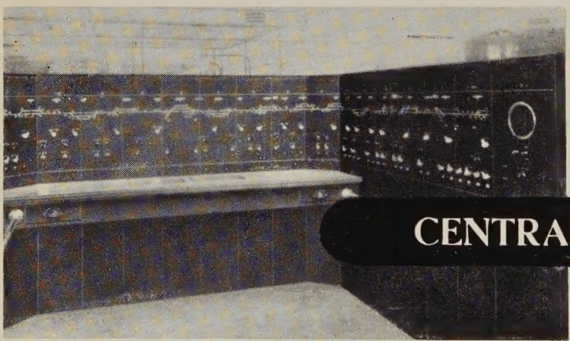

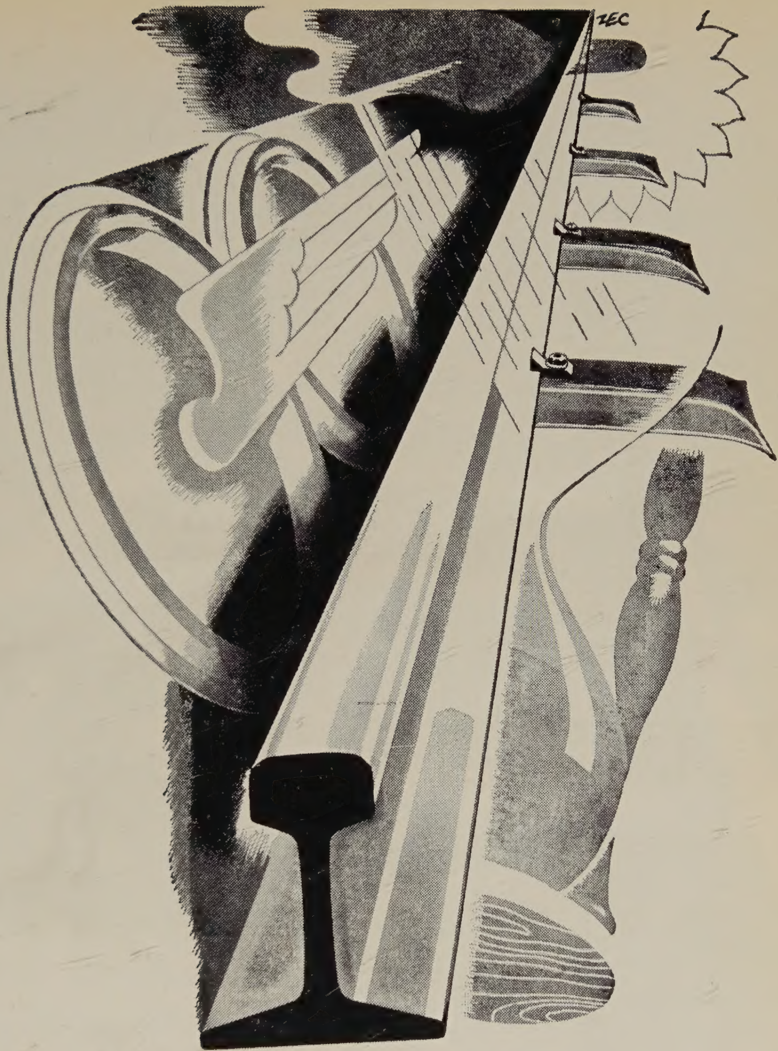

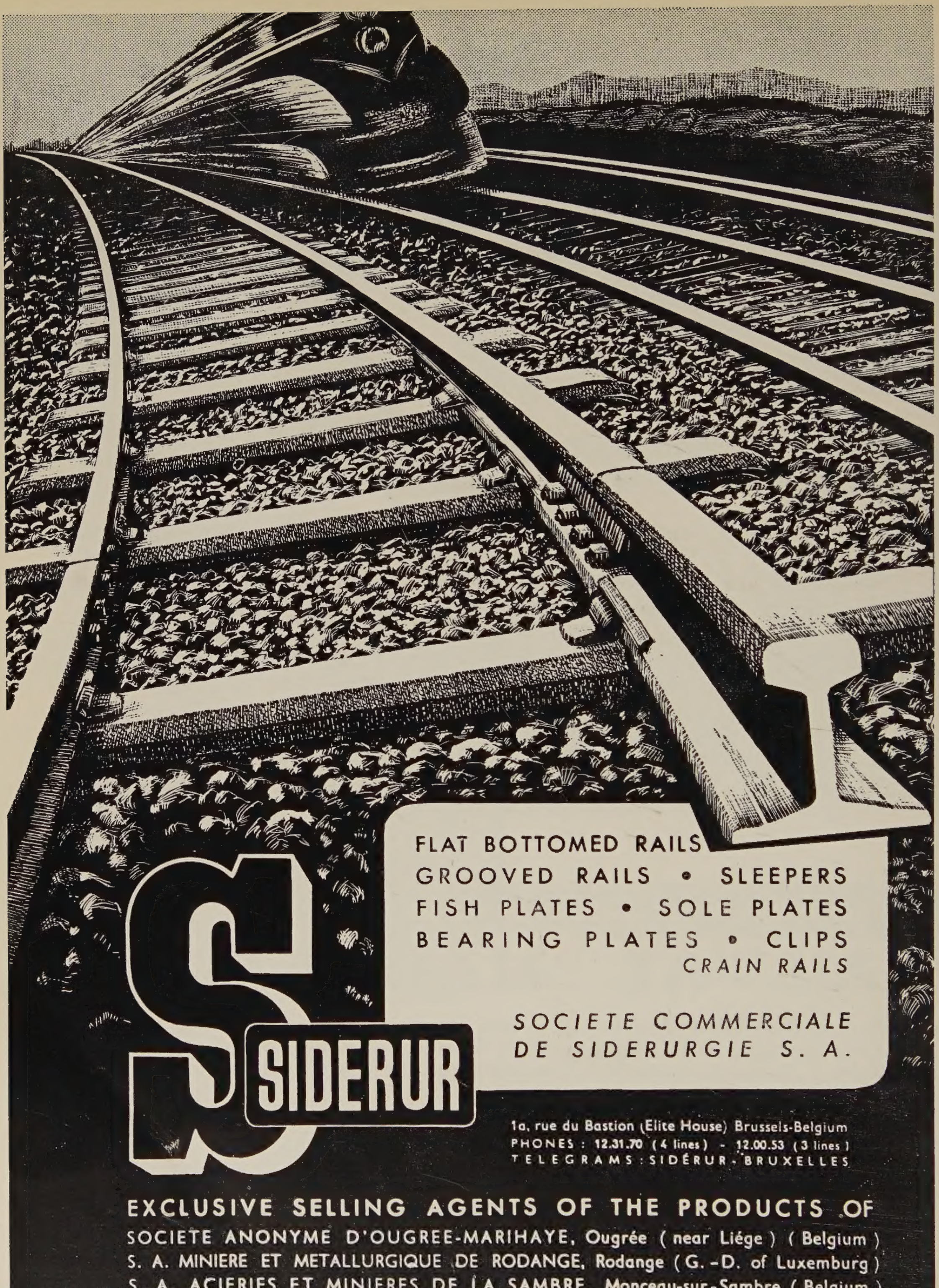
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OF THE

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(ENGLISH EDITION)

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An edition in French is also published.

Bulletin of the International Railway Congress Association

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Vol. XXXII. — No. 9. September 1955.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .337]

Individual axle drive.

Mechanical systems used on electric locomotives and motor coaches, with an indication of the results obtained in service on railways of all kinds,

(Continued)*

by Adolphe-M. HUG,
Consulting Engineer, Thalwil (Zurich), Switzerland.

Still dealing with notched (or crenellated) couplings, we show in figure 524 an arrangement for high-frequency vibration testing.

To differentiate between transmission for locomotives (heavy duty) and transmission for tramways (or light local railways) we are including, as a supplement to figure 522, two figures Nos. 525 and 526. In the case of tramways, of course, the wheel diameter is less and the power is about 100 HP per axle.

Photo SAAS.

Fig. 524. — Crenellated coupling subjected to high-frequency vibration tests. The bottom supports are placed, one under the lever arm (left) and the other under the right-hand end of the driver.

The advantages of the Secheron IV mechanism with cardan shaft and leaf-pring coupling may be summarised as follows :

a) it needs no lubrication and has no parts which require periodical replacement, because there are, in effect, no parts working under friction; movement of the axle in relation to the motor causes deflection of the leaf-springs only;

b) because of their thinness, the leaf-springs allow the cardan shaft a high degree of angular deviation;

c) in the axial plane, where space is usually restricted, the dimensions of the leaf-springs are small;

(*) See *International Railway Congress Bulletin*, for February 1953, p. 65; May 1953, p. 245, November 1954, p. 1069 and July 1955, p. 469.

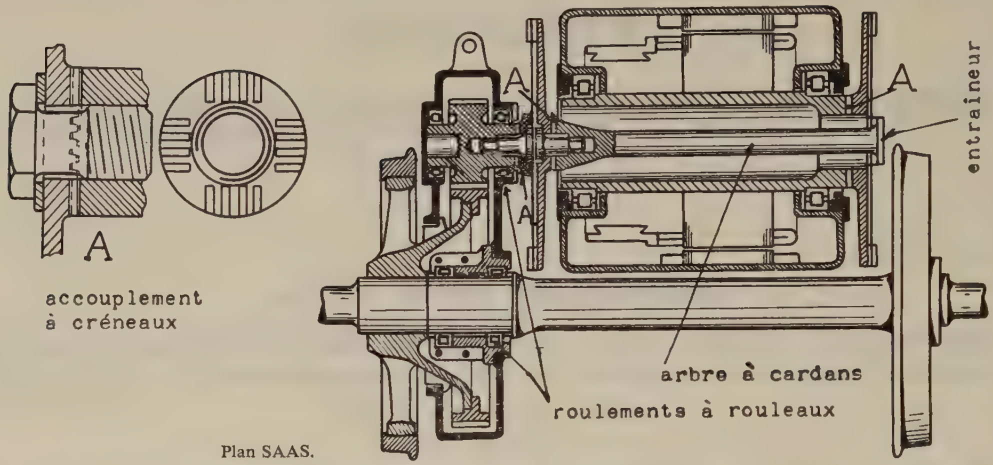


Fig. 525. — Secheron IV (leaf-spring) mechanism, type for locomotives (or heavy duty rail motor coaches) of high power. At each of the points marked A a crenellated coupling A (left) is located in the centre line of the armature shaft (centre line of the transmission), to facilitate assembly and dismantling. Cf. fig. 523 and 526.

N. B. — A fourth crenellated coupling can be placed if desired between the cardan shaft and the driver on the right.

Explanation of French terms : accouplement à créneaux = crenellated coupling. Arbre à cardans = cardan shaft. Roulements à rouleaux = roller bearing. Entraîneur = driver.

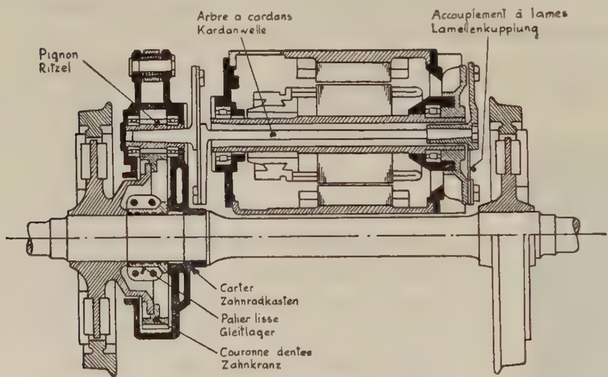


Fig. 526. — Secheron IV mechanism, for tramways (low powers). Differing from that in figure 525, the gearcase is mounted on the axle by means of a plain bearing (white metal). This also shows the resilient wheels of figure 371.

Explanation of French terms :

Pignon = pinion.
Arbre à cardans = cardan shaft.
Accouplement à lames = leaf-spring coupling.
Carter = gearcase.
Palier lisse = plain bearing.
Couronne dentée = geared ring.

Block SAAS

d) the leaves are very flexible in the axial plane, i.e. perpendicular to them. This facilitates the mounting of the motors, the position of which, relative to the gear case, does not call for excessively precise location;

e) the simple form of the leaf-springs, which are in effect bars supporting forces at both ends, makes it easy to calculate with reasonable accuracy the stresses to which they will be subject;

f) similarly, because of their simple shape, the leaves can be manufactured from high-quality spring steel (which can moreover be cut along the direction of rolling) which will take very high stresses;

g) the leaf-springs are relatively cheap and their very infrequent replacement

increases the cost of maintenance to a very slight degree only.

We now proceed to *applications* of this Secheron IV driving mechanism. We have already mentioned the earlier ones, which are recapitulated below :

1) *one* of the seven *motor coaches* of the Emmenthal (EBT Railway, series 141, class CFe $^4/_4$ (see figs. 187, 372-373 and 461, motor coach No. 148), standard gauge, for 15 kV, 16 $^2/_3$ cycles, single-phase, put into service in 1948;
2) *three motor coaches* of the Neuchatel Tramways, Nos. 81 to 83 (see previous figures 259 to 261 and note 379) 1 m gauge, 650 V D.C., power 200 HP, maximum speed 60 km (37 miles)/h put into service in 1947;
3) the prototype *motor coach* No. 571 (since 1953, renumbered 100, the air brake having been removed) of the Rotterdam Tramways (RET) (figs. 374-376 and 517), standard gauge, 550 V D.C., one-hour rating 340 HP maximum speed 60 km/h put into service in 1948;
4) *Eight* of the twenty-five *motor brake vans*, Fe $^4/_4$, type B_0-B_0, series 801, of the Swiss Federal Railways, Nos. 802 to 805, 817, 819, 820 and 831 (fig. 444, 518 to 521 and 527) ([383]); standard gauge, 15 kV, 16 $^2/_3$ cycles, single phase, put into service 1950/53

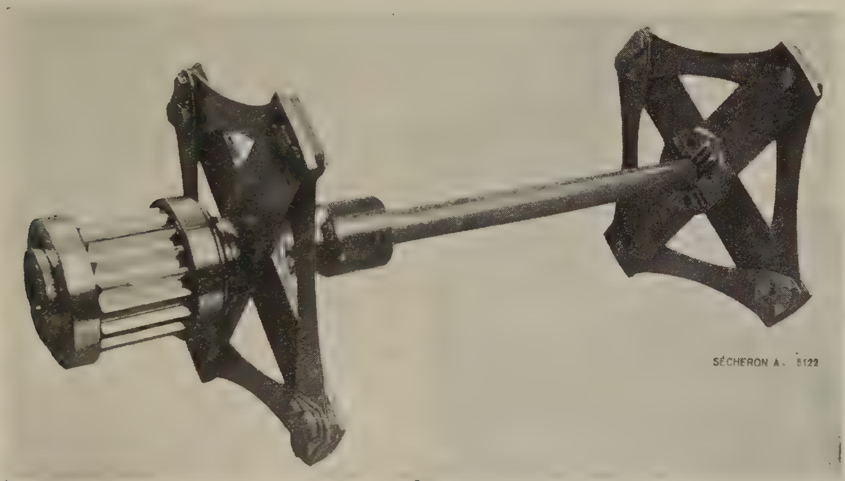
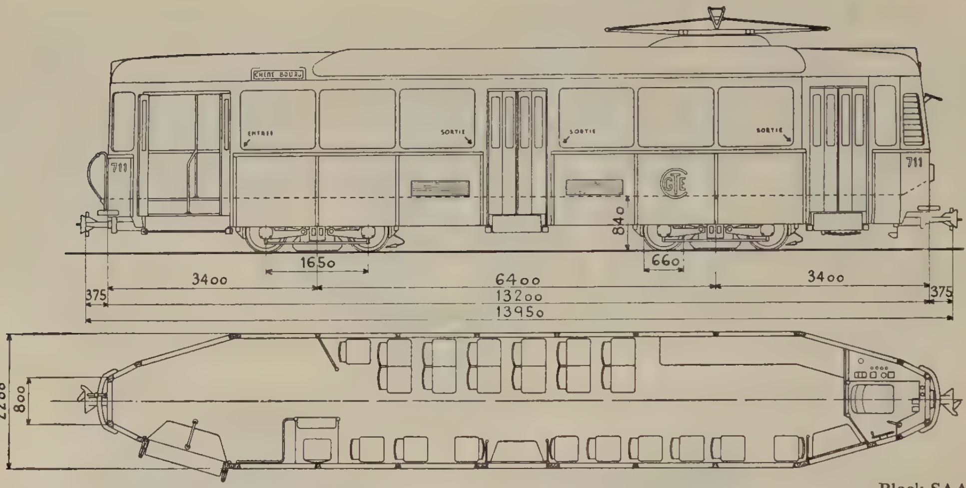


Fig. 527. — Cardan shaft (passing through the hollow armature shaft), with drivers, leaf-springs, crenellated couplings and pinion, for the motor brake vans, series 801 of the CFF (fig. 444 and 518 to 521).

([383]) See pages 54-55 ([360]) and 109-110 (*Congress Bulletin*, July 1955, pp. 473-474). — The four new SWS bogies of the motor brake vans 803 and 819 were delivered in 1950. The older bogies of Nos. 802, 804, 805, 817, 820 and 831 were converted by the CFF Works at Yverdon; that is, adapted for the new motor suspension with SAAS leaf-spring drive (see figs. 518 to 521), Nos. 821 to 824 (Fe $^4/_4$, No. 824 one bogie only, the other having Secheron 1 spring mechanism, see bottom of page with fig. 444) are fitted with Oerlikon VI mechanism with rubber pads as in figures 442-443.



Block SAAS.

Fig. 528. — Elevation and plan of motor coaches, series 701, of the Geneva municipal transport system, CGTE. Cf. figure 250, Zürich VBZ.

Photo SAAS R. 1385.

Fig. 529. — Motor coach No. 704 with trailer No. 308, in service on the Geneva municipal system CGTE (fig. 528).

N. B. — Almost all the modern motor coaches of the Swiss tramways have a similar appearance and arrangement.

(originally, before modernisation, 1927/28);

5) The *thirty series* 701 motor coaches of the Geneva Transport Authority CGTE (see fig. 107*a*, 107*b* and 371); 1 m gauge, 550 V D.C. These motor coaches were put into service successively in 1950/51; figures 528 and 529 give a dimensioned plan and elevation and a view in service with a trailer (384); figure 526 shows a section through the horizontal centre line of one of the complete driving axles, and figure 530 shows a cardan shaft. These motor coaches have a one-hour rating of 260 HP (at 33 km [20 miles] /h), maximum speed 55 km (34 miles) /h, number of passengers 100 (27 seated), tare 16 tons, of which 3.7 tons

(384) See *L'Industrie des Voies Ferrées et des Transports automobiles*, Paris (journal of the Union des Voies Ferrées UVF, France), Jan. 1951, « Modernisation of the Geneva Tramways », 7 p., 14 figs., E.G. CHOISY.

See also *Bulletin Sécheron*, Geneva, No. 23F, 1952, « Some new features introduced into the motor coaches of the Geneva Tramway », pp. 1-11, 18 figs. and diagrams, H. WERZ.

is the electrical equipment, total loaded weight 23.5 tons. The manufacturers of the mechanical parts were Schindler-Waggon Co SWP of Pratteln, near Bale, and of the electrical equipment, the Secheron (SAAS) Works, Geneva.

Items 1) to 5) refer to Switzerland [except No. 3) - Holland] as also do 6), 7) and 8) below (still dealing with Secheron IV mechanism) :

Fig. 530. — Cardan shaft of the motor coaches, figures 528 and 529. This combined part is exactly the same as figure 526 (see also figure 107*a* and *b*).

6) *twelve* of the thirty-one rail *motor coaches*, class CFe $^4/_4$, series 841, numbered 841 to 844 and 864 to 871, of the Swiss Federal Railways (see figs. 531 and 532), one-hour rating 1 600 HP (15 kV 16 $^2/_3$ cycles, single phase), maximum speed 100 km (62 miles)/h ([385]).

The manufacturers of the mechanical parts are the SLM-Winterthur for Nos. 841 to 868 and Schindler-Pratteln SWP for Nos. 869 to 871, the electrical equipment of the 31 motor coaches has been supplied by three companies in collaboration; Oerlikon MFO (traction motors), Brown-Boveri BBC (transformers), Secheron SAAS (control and running gear);

7) *three motor brake vans*, series 401, Nos. 401-403, class Fe $^4/_4$, 720 HP, maximum speed 60 km/h, and *eight motor coaches*, series 601, Nos 601-608, class CFe $^4/_4$, 440 HP one-hour rating, maximum speed 60 km (37 miles) /h of the Jura Railways CJ which has electrified, with 1 500 V D.C., its narrow (metre) gauge lines ([386].) See figures 533 to 535. The builders of

([385]) This type of motor coach (of which prototype No. 841 has been in service since May, 1952) was designed for fitting either with the Secheron IV leaf-spring or the Brown-Boveri disc transmission (both with cardan shafts). The same traction motors and the same axles can be used for both systems of transmission.

— The nineteen other motor coaches of the same type, Nos. 845 to 863 have the Brown-Boveri disc transmission, as described under the heading of disc complings.

See : « The CFe $^4/_4$ motor coaches Nos. 841-871, 1 600 HP, of the Swiss Federal Railways » in the *Bulletin Oerlikon*, Zürich, No. 298, June 1953 (particularly figs. 1, 4, 7, 8 and 9), L.H. LEYVRAZ and G. DEGEN.

See also : « New motor coaches and trailers of the Swiss Federal Railways » in the *Basler Nachrichten « Technik »*, Bale, No. 197, 12-5-54, 2 p., 9 fig., E. MEYER (dealing also with the motor coaches of note ([387]), 2 figs. and those of the SOB system (fig. 493) and SMB (fig. 461).

([386]) The CJ system includes the following lines : normal gauge, Porrentruy to Bonfol and, metre gauge, from La Chaux-de-Fonds to Glovelier and from Tavannes to Le Noirmont. The CJ intends to equip its rolling stock with fully-suspended motors because its permanent way still includes sections of light rail of less than 20 kg per metre. See the conclusion of the article in note ([385]).

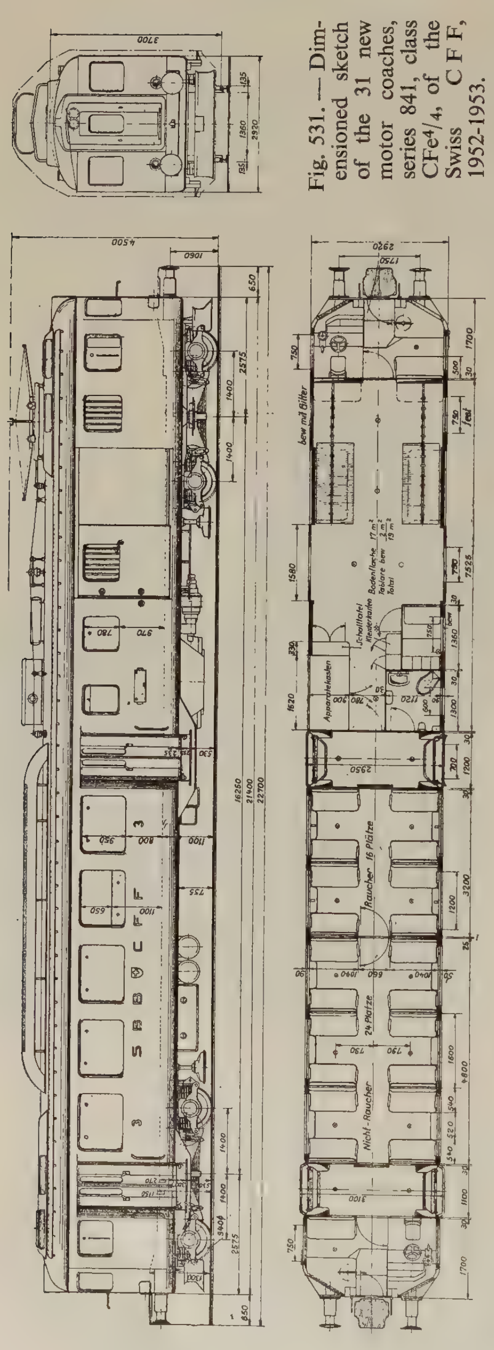


Fig. 531. — Dimensioned sketch of the 31 new motor coaches, series 841, class $CFe^4/_4$, of the Swiss C F F, 1952-1953.

Plan CFF.

Fig. 532. — Motor coach No. 841, $CFe^4/_4$ of the CFF (first of the series of fig. 531), in service with a pilot coach (reversible set).

Builders of the pilot coach, SWP (Schindler-Waggon, Pratteln, near Bale).

N. B. — Motor coach No. 841 (prototype) has been in service since May 1952, on the Bellinzona-Locarno line, Tessin canton. The following coaches have been put into service successively on various secondary lines since March 1953.

Photo CFF.

Photo SAAS A. 5427.

Fig. 533. — Motor brake van No. 401, $Fe^{4}/_{4}$ class, 1953, of the Swiss Jura Railway, CJ.

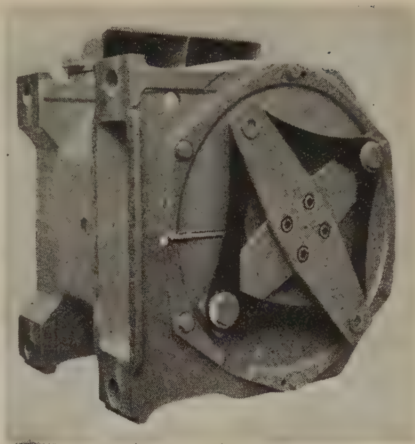


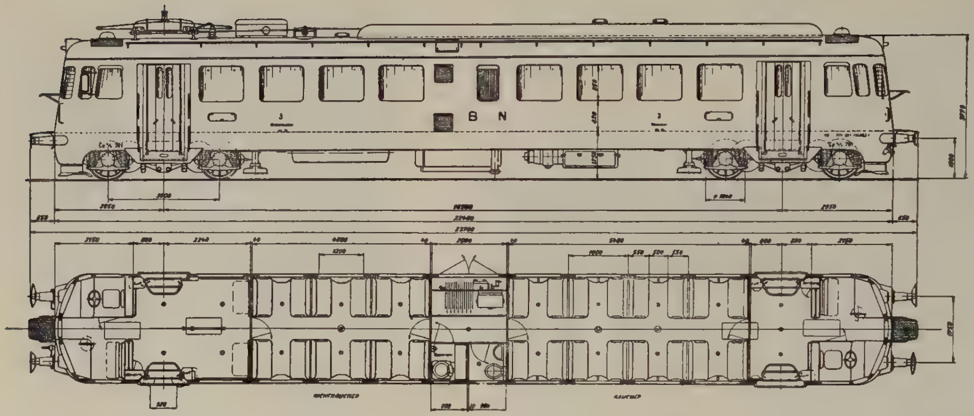
Photo SAAS A. 5348.

Fig. 534. — 180 HP traction motor, wholly suspended, with Secheron IV leaf-spring coupling, of the CJ motor brake van, series 401, of figure 533. This shows the two drivers on the side opposite to the pinion, linked at the ends to the springs (black).

these eleven motor vehicles are the SIG Company of Neuhausen-Schaffhouse for the mechanical parts and Secheron, Geneva, for the electrical equipment. Figure 534 shows a motor with the leaf-spring coupling for one of the vehicles in figure 533.

Fig. 535. — Motor coach No. 604, class $CFe^{4}/_{4}$, of the Swiss Jura Railway, CJ, at Noirmont station, with pilot coach (reversible set).

Photo SAAS A.5426.



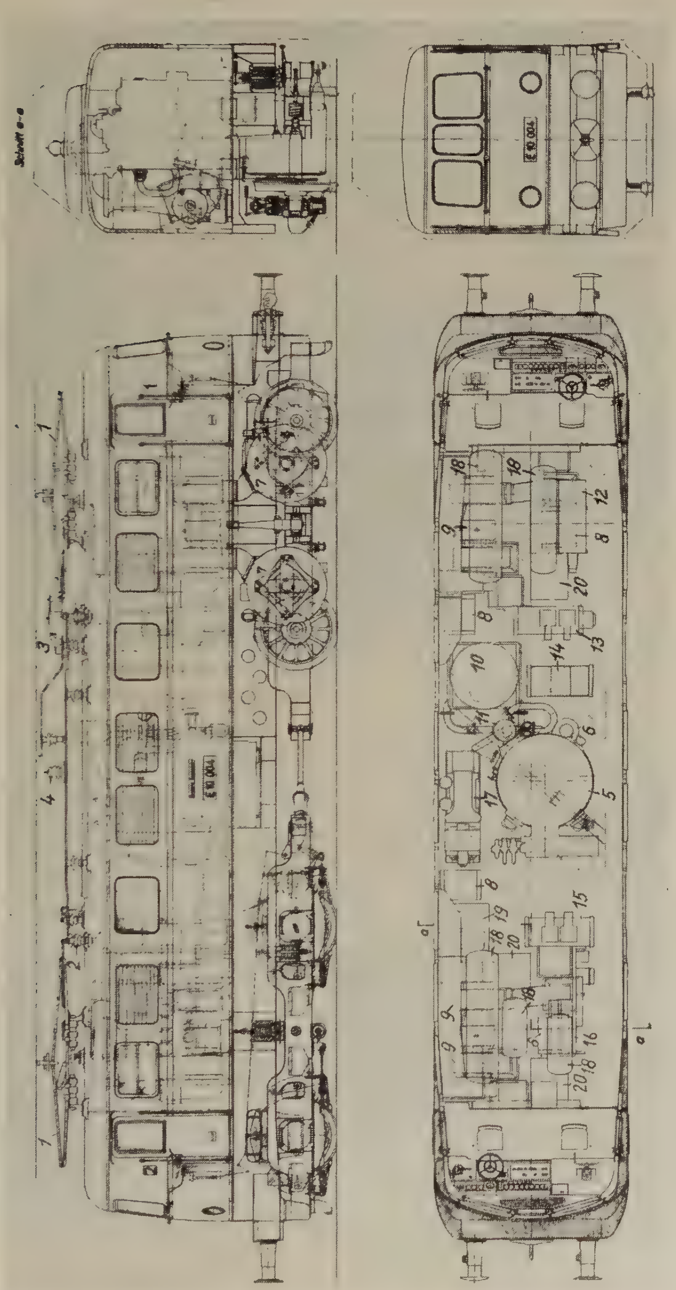
Plan BLS R. 202.

Fig. 536. — Dimensioned sketch of motor coaches Nos. 761 and 762, class $Ce^4/_4$, of the Berne-Neuchatel, BN., direct line (BLS system). One-hour rating, 2 000 HP. Maximum speed 110 km/h.

Fig. 537. — Motor coach No. 761 (fig. 536) of the Berne-Neuchatel BLS/BN railway, with a train at Kandersteg (Lötschberg) station.

Photo SAAS A 5431.

8) *two motors coaches*, Nos. 761 and 762, class $Ce^4/_4$, for passenger service only on the direct line Berne to Neuchatel (BN) of the Bernese Alps BLS Railway, which has already been noted on many occasions. These two motor coaches, with torsion bar suspension for the bogies, with a one-hour rating of 2 000 HP, put into service in the summer of 1953, are probably the world's most powerful 4-axle alectric motor coaches for passenger service; they have a



Block « Die Bundesbahn ».

Fig. 538. — Elevation, sections, plan and front view of the locomotives (prototype), series E 10, Nos. .004 and .005, of the West German DB, with Secheron IV mechanism. The dimensions are the same as figure 478 (prototype E 10 003).

body length of 22.4 m (see figs. 536 and 537) ([387]).

The main details are as follows :

one-hour rating of four motors	2 000 HP
one-hour tractive effort at rail at approximately 70 km (43 miles)/h	8 200 kg
maximum tractive effort at rail (starting)	13 000 kg
maximum speed in service	110 km (68 miles)/h
diameter of wheels	1 040 mm
gear ratio	1 : 2.484
weight of mechanical parts	41 tons
weight of electrical equipment	27 t
tare	68 t
total loaded weight	74 t
corresponding axle load	18.5 t
number of seats (including 4 tip-up)	64

brakes : Westinghouse dual, Rapid, rheostatic and anti-slipping.

The manufacturers of the mechanical parts are the Société Industrielle Suisse, SIG, Neuhausen (Chute du Rhin) and of the electrical equipment Secheron SAAS, Geneva.

Finally, with regard to applications of the Secheron IV in other countries, mention may be made of the following :

9) *Two prototype locomotives*, Nos. E. 10.004 and 10.005, $B_0'B_0'$ type, of the West German Federal Railways DB ([388]) of which the general arrangement and dimensions are similar to those of figure 478. Figure 538 shows them in elevation, various sections, plan and front elevation; figure 539 shows the arrangement of the bogies of locomotives Nos. E. 10.003 to .005 and figure 540 the cardan shaft assembly with drivers and springs and the gear gear; finally, figure 541 shows locomotive No. E. 10.004. The one-hour rating is 4 350 HP, maximum speed in service 120-130 km (74-80 miles)/h.

The two locomotives Nos. E. 10.004 and .005 had the mechanical parts supplied (as for 10.003) by HENSCHEL, of Kassel, the electrical equipment being supplied by AEG and BBC-Mannheim.

10) *Twenty-two motor coaches*, Nos. 340 361, with four driving axles, of the metre-gauge local railway « Vestische

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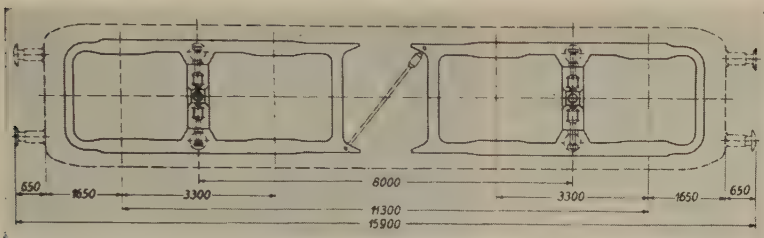
([387]) See *Der Oeffentliche Verkehr*, Berne, No. 8, 1953 (Journal of the Entreprises Suisses de Transport, private, municipal and moutain railways, etc.), « New motor coaches of the Bern-Neuenberg Railway », 1 fig. and various historical notes.

([388]) See note ([296]), p. 50 (*Congress Bulletin*, May 1953, p. 256).

See also *Die Bundesbahn*, Cologne/Darmstadt (Journal of the HVD, central administration of the DB), No. 3, Feb. 1953, « New $B_0'B_0'$ electric locomotives, series E 10 », 5 p., 12 figs., table, E. KILB.



Block « Die Bundesbahn ».

Fig. 539. — Bogie arrangement of the prototype machines, DB series E 10, Nos. .003 to .005, of figures 538 and 478. This shows the flexible link between the bogies, and the oscillating pivot device of figures 435 and 436.

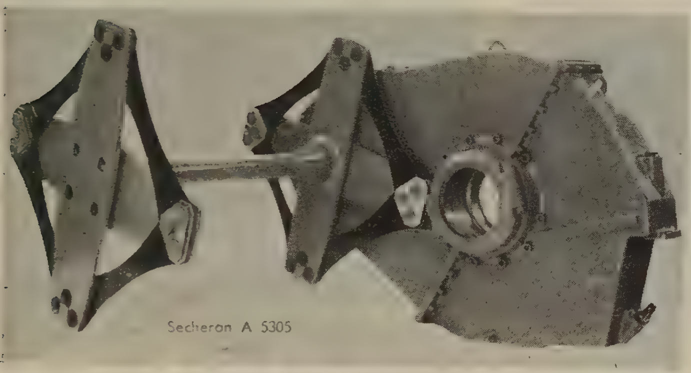


Photo SAAS A. 5305.

Fig. 540. — Transmission group of the machines in figure 538, comprising :
— the cardan shaft, passing through the hollow armature shaft of the traction motor;
— at each end of the cardan shaft, the drivers with the leaf-spring couplings;
— the gear case. The latter is suspended by a pendulum link from the bogie frame.
This transmission is designed for a one-hour power of 1100 HP per axle, with a torque load of of 89 500 kgcm at 870 r.p.m.

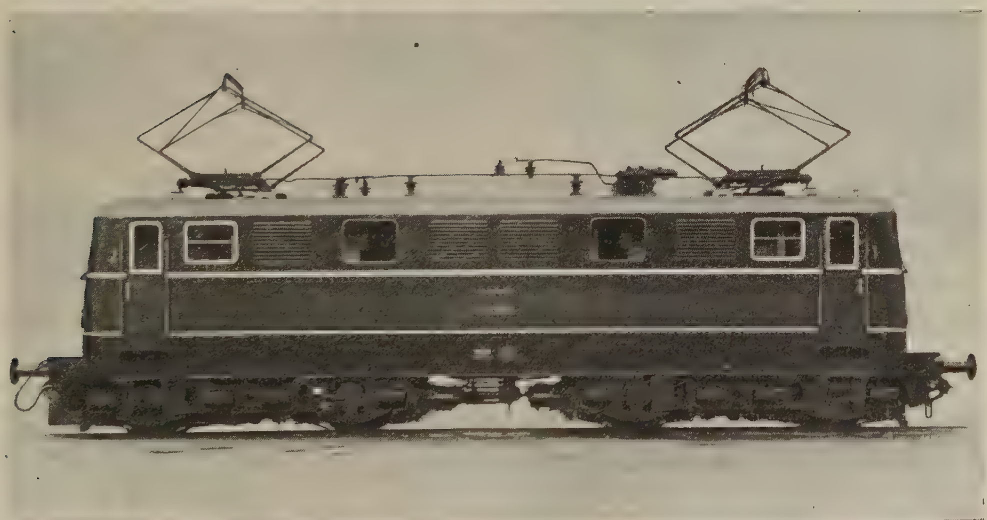


Photo DB.

Fig. 541. — $B_0'B_0'$ electric locomotive, prototype No. E 10 004 (figs. 538 and 539) of the German DB (Henschel-AEG), fitted with the transmission in figure 540 (cf. fig. 478).

Strassenbahn » of Herten (Westphalia), 600 V D.C., put into service successively in 1952 and 1953. Hourly rating 280 HP (4 GB 55 am motors with hollow armature shaft); maximum speed 60 km/h. Figure 542 shows one of the coaches in service (the trailers are similar), figure 543 a

Photo Kiepe 197/F.

Fig. 542. — Motor coach No. 340, the first of 22 motor coaches, series 340 and 352, metre gauge, with two driving bogies and « Compact » automatic drawgear (see fig. 543) of the « Vestische Strassenbahnen » at Herten in Westphalia (see fig. 543).

dimensioned sketch of coaches Nos. 340 to 351, figures 544 and 545 the bogie with motors and transmission. Spur gears with a ration of 1 : 6.71 (wheel diameter 660 mm). The manufacturers of the mechanical parts are the Düsseldorf Waggon fabrik DUWAG, already mentioned; electrical equipment was supplied (under Secheron licence) by the « Ateliers Electrotechniques Th. KIEPE of Düsseldorf-Reisholz; the motors (under Secheron license) by the GARBE-LAHMAYER Works.

It may be noted that these coaches can work in either direction with passenger access and exit on either side as required; they are operated partly in joint working with neighbouring systems.

11) *A prototype motor coach* No. 201 of the Bochum-Gelsenkirchen (Ruhr industrial basin) Tramways, similar to the coaches in item 10), but for normal gauge of 1435 mm and with 260 HP [four motors of the same type as item 10) and item 12)], 600 V, D.C. (fig. 544).

12) *Two tramway bogies* of the Hamburg Tramways, « Hamburger Hochbahn AG. » (HHA.). Details are similar to those of the coach in item 11). Figures 546 and 547 show the bogie with Secheron IV transmission for the Hamburg class V6 and V7 tramways. These bogies are held as spares and are interchangeable with other types.

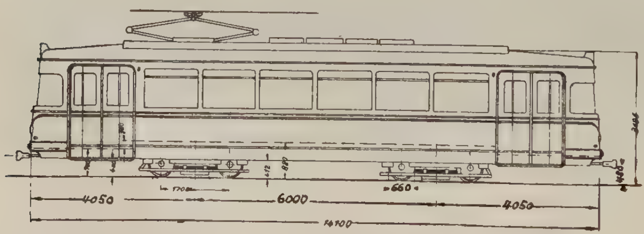


Fig. 543. — Dimensioned sketch of the first 12 motor coaches of the series in figure 542. The following ten, Nos. 352 to 361, which have a more streamlined end, also have a central door on each side (narrower, as on the right).

Plan CX32 Vestische Strassenbahnen.

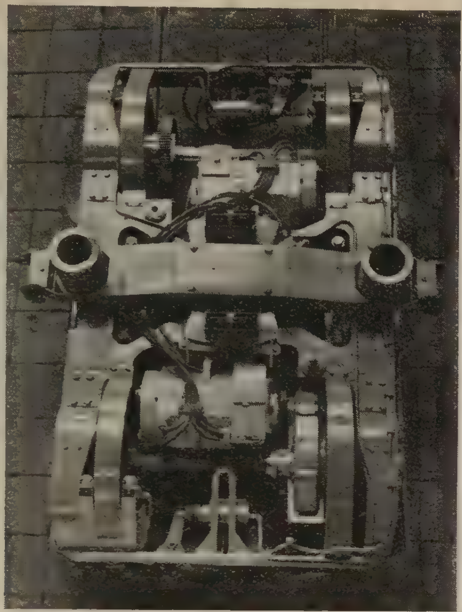


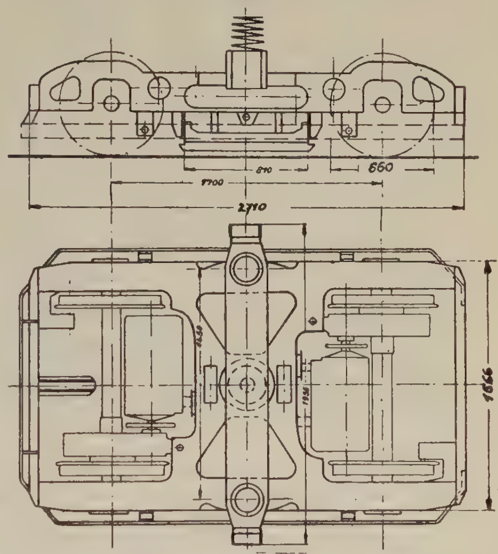
Photo : Vestische Strassenbahnen.

Fig. 544. — Top view of a bogie of the motor coaches of figures 542 and 543. This shows at the ends of the armatures of the two motors, the leaf-spring coupling. The lower motor group is complete; in the upper group, the gearcase and pinion are dismantled. The same bogies were also fitted to motor coach No. 201 of the Bochum tramways. The motor group, with transmission weight 420 kg (per axle).

They have a gear arrangement which differs from that of the coaches in items 10) and 11). Efforts have been made in this case to reduce the unsprung weight to a minimum, even the axles; the wheels are not only rubber mounted, they also have centres of light metal (see fig. 547).

Czechoslovakia.

13) Seventeen main-line locomotives, type $B_0'B_0'$, class E 499.0, Nos. E 499.01 to 17, one-hour rating of 3 260 HP, 3 kV D.C., maximum speed 120 km (74 miles/h of the Czechoslovakian State Railways, « Ceskoslovenské Státni Dráhy » CSD [389]. These machines, of which figure 548 is a dimensioned sketch, have been put into service successively since the summer of 1953. They were built in Czechoslovakia under Secheron license for the electrical equipment and SLM-Winterthur license for the mechanical parts.



Plan : Vestische Strassenbahnen.

Fig. 545. — Elevation and plan of bogie of figure 544 (motor coaches 542 and 543). Cf. figures 495 and 496, same constructor DÜWAG, but of a completely different type.

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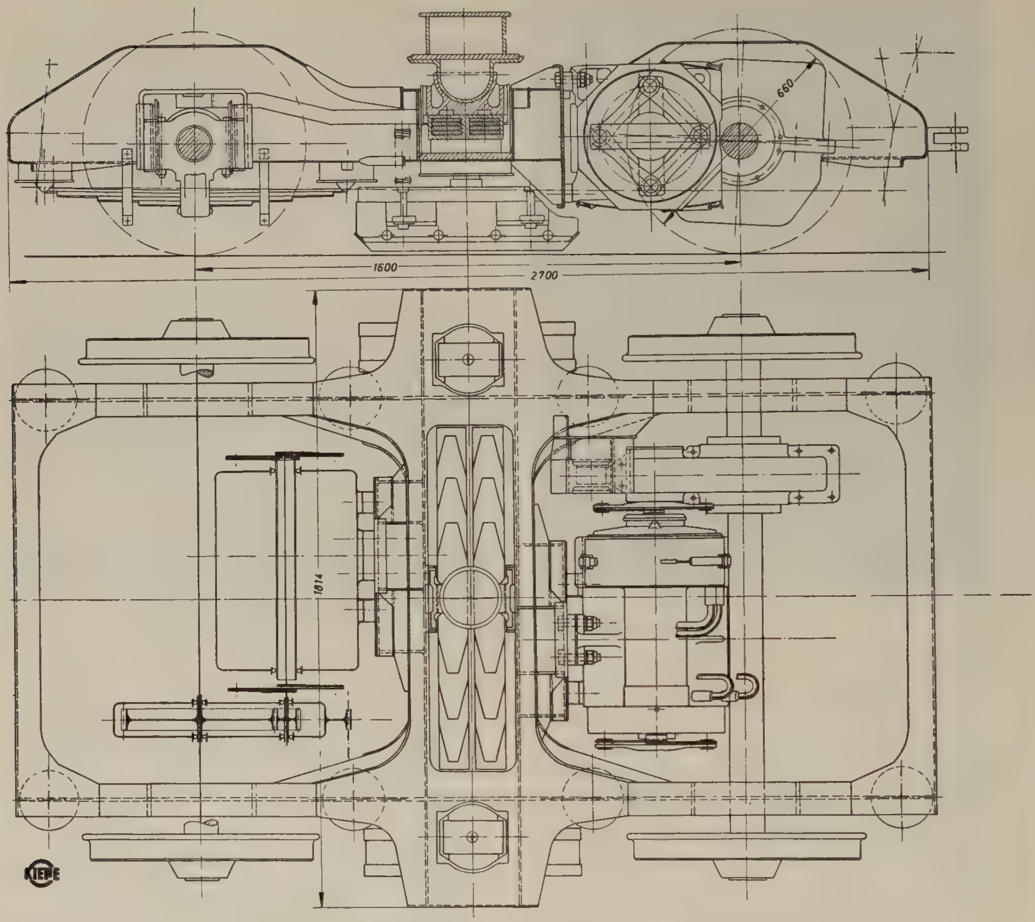
[389] See *Vol. I*, pp. 56-60 and p. 30, figs. 120 to 125, regarding the 1500 V D.C. machines for the Prague suburban lines (Skoda transmission for series E.466, type 1A-AA-A1, Buchli type for E 465, type 1Do1). All other locomotives for overhead contact lines or for battery operation (shunters) have nose-suspended motors.

See also the second publication mentioned in note [45], p. 54 of *Vol. II.*

Also the Revue *Strojirenstvi*, Prague, No. 3, 1953, « Electrisace ČSD a nová elektrická lokomotiva $B_0'B_0'$ », pp. 178 to 184, 10 figs., diagrams and table, J. HANYK.



Plan : Kiepe SK 2439.

Fig. 546. — Elevation and plan, with part section and diagrammatic arrangement (left) of the spare driving bogies with Secheron leaf-spring transmission (hollow armature shaft); tramway motor coaches class V6 and V7 of the Hamburg tramways HHA.

The mains details are as follows :

one-hour mating . . . . 3 260 HP at speed =	58 km (36 miles)/h
maximum tractive effort	21 000 kg
gear ratio	1 : 2.27
maximum speed in service	120 km (74 miles)/h
weight of mechanical part	44.5 t
weight of electrical equipment	35.5 t
total weight (adhesive)	80 t

These locomotives were constructed entirely by the SKODA Works at Pilsen (both mechanical and electrical parts).

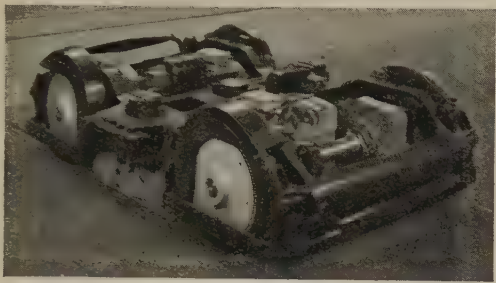


Photo : HHA 1367.

Fig. 547. — Bogie of figure 546, complete in running order. The wheels are resilient (2 × 7 discs, rubber mounted) of the Heinrichshütte (Ruhr) type, as in the sixth sketch of figure 409. The wheel centres are entirely constructed of light metal.

Oerlikon mechanism with cardan shaft, plates and leaf springs (390).

We are calling this mechanism Oerlikon VI since there are already five other completely different types developed by the Oerlikon Works MFO, Zurich (391).

The flexible transmission shown diagrammatically in figure 377 has been developed since 1949, in the sense that for certain applications the leaves are provided at both ends of the armature, or bilaterally, as in the Secheron IV mechanism described earlier. We have already described the Oerlikon VI mechanism (390) the new arrangement of which is shown in figures 551 to 554.

There are only two new applications to report, viz :

1) a French SNCF motor coach (for main-line railway service), No. Z 9051 for 20 (25) kV 50 cycle single phase with direct motors, and

2) seventeen tramway coaches in Switzerland, twelve for the Zurich tramways (VBZ) and five for local lines operated by the VBZ in the Zurich and Glaris cantons.

With regard to item 1). — Figures 549 and 550 show the SNCF motor coach and driving trailer sets No. Z 9051 + ZS 19051 (392). This set is one of the 24 put into service in 1925 on the Paris

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(390) See *Vol. II*, pp. 185 and 296 to 300 (fig. 377 to 381) (*Congress Bulletin* for January 1950).

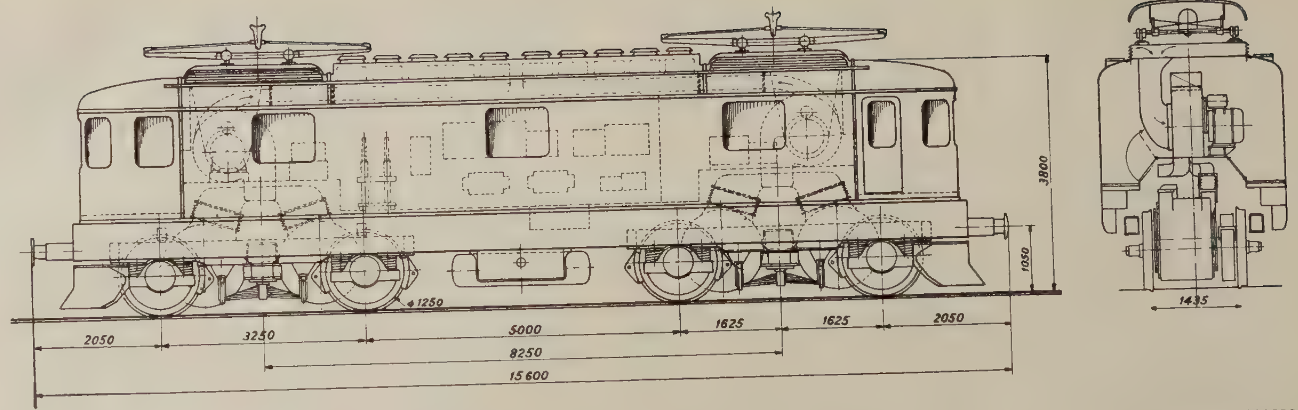
(391) Earlier Oerlikon transmission mechanisms :

I : 1921, figs. 113, 114, 116 and 119 (Switzerland and France) of *Vol. I*;
II : 1927, figs. 150-153 (India) of *Vol. I*;
III : 1937, figs. 143-145 (Switzerland) of *Vol. II*;
IV : 1943, figs. 197-198 (Switzerland) of *Vol. II*;
V : 1948, fig. 342 (Switzerland) of *Vol. II*, and *Congress Bulletin*, May 1953, fig. 442-444 *(Vol. III)*.

(392) See RGCF., Nov. 1951 (special number in connection with the Annecy 50-cycle scheme), pp. 705-707, 6 figs., diagram and 2 tables, « Motorcoach Z 9051 + ZS 19051, direct motors, Oerlikon, 50-cycles, SNCF ».

— *Bulletin Oerlikon*, Zurich, No. 293F, August 1952, pp. 25 and 30-37, 12 figs., diagram and tables, « 1730 HP motor coach set for suburban service, Z 9051 + ZS 19051, 50-cycle, single-phase, of the SNCF », L.H. LEYVRAZ, C. BODMER, G. DEGEN (also a German edition No. 293).

See also the same publication, No. 285, Sept.-Oct, 1950, under B, pp. 2082-2083, 1 fig.



Plan SAAS L. 113899.

Fig. 548. — Diagram (elevation and cross-section) of the 17 B_0B_0 locomotives, series E 499.01-17, for 3000 V D.C. of the Czechoslovakian Railways ČSD, 1953.

N. B. — This sketch is not definite. The bogie wheelbase is 3330 mm and the pivot spacing is 8170 mm. See fig. 1 of the article at the end of note (389), where the machine is designated B_0B_0 12 E 1. These locomotives have to operate at a line tension of between 2000 and 3600 V.

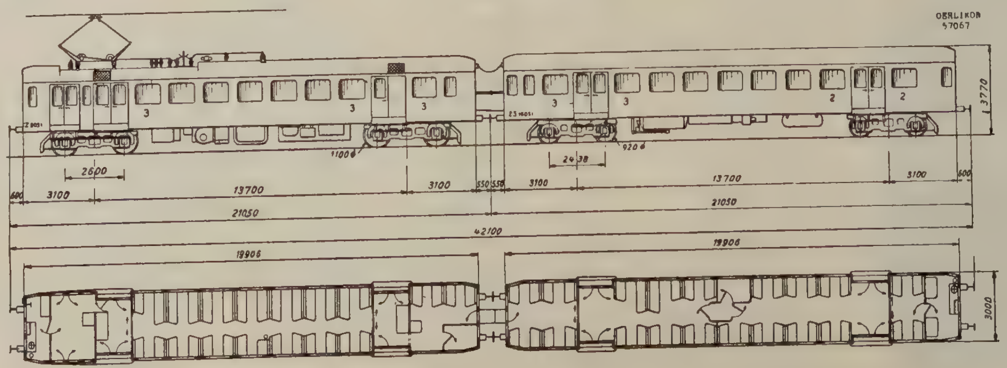


Fig. 549. — Plan and elevation of the motor coach set, for 20 (25) kV, 50-cycle, single-phase, of the French SNCF, comprising the motor coach Z9051 and driving trailer ZS 19051 (right). La Roche-sur-Foron-Annecy - Aix-les-Bains (Haute Savoie) (maximum gradient 16 $^0/_{00}$).

South suburban (PO line from Paris Austerlitz to Dourdan/Etampes, 1500 V D.C.) ([393]); it was converted for its new service. Details are as follows :

one-hour rating at the armature shafts : 1780 HP at 57.5 km/h (36 miles/h);

corresponding tractive efforts at rail : 8160 kg;

maximum speed in service : 80 km (50 miles)/h;

tare, 64 + 42 = 106 tons; loaded 118 tons;

total load per driving axle : 17.5 tons.

coach No. Z 9051 of the SNCF, which by the end of 1953 had run more than 225 000 km. After 12 000 km, however, the shape of the springs had to be modified to that shown in figure 559.

The principle of its operation is as follows : the rotor transmits the torque directly through the primary leaf spring coupling to a torsion shaft at the far end of which is fitted a second leaf spring coupling fixed to the pinion. Under the Oerlikon patent design, the first of these spring couplings is located

Fig. 550. — SNCF motor coach Z 9051 + ZS 19051, of figure 549, on a siding at Annecy station, in winter.

Photo Oerlikon 55724.

inside the motor, which allows the latter to be completely enclosed at the commutator end and thus save valuable space. The spring coupling is accessible through apertures in the end carrying plate (fig. 555).

The gear case, of welded steel plate, is supported at one end on the driving axle by two roller bearings (lower E of fig. 552) and at the other end it is carried

Motor coach No. Z 9051 has its four driving axles fitted with transmission of the Oerlikon VI heavy duty type.

Figures 551 to 556 show the arrangement and the component parts of this particular equipment and the key to these figures will complete the description of it.

The Oerlikon leaf spring equipment has given satisfactory service on motor

([393]) See pp. 268 and following (fig. 194-200) in « The partial electrification of the Orleans system », H. PARODI, extract from the RGCF, 1928, Dunod, Paris.

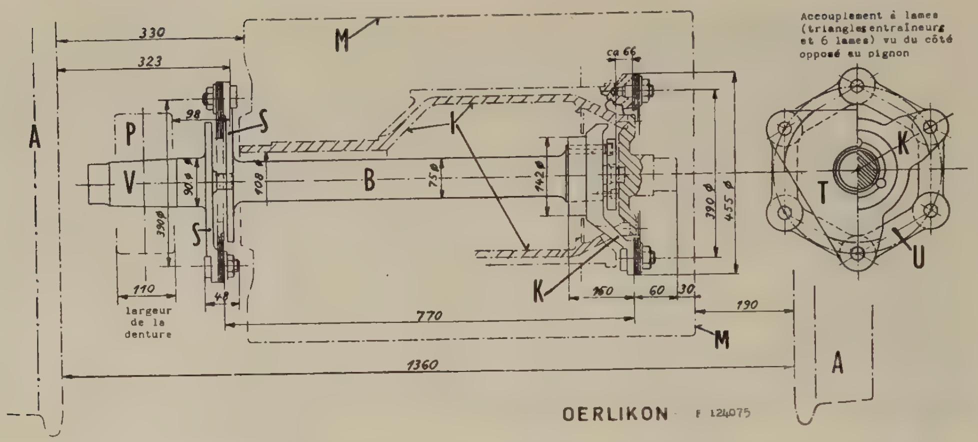


Fig. 551. — Oerlikon VI drive mechanism of SNCF motor coach Z 9051, figures 549 and 550. Section through centre line of traction motor and cardan shaft. Right, central view of mechanism at the side opposite to the pinion.

A = driving wheels;

M = profile of traction motor (fig. 553).

I = hollow armature shaft (hatched).

B = cardan shaft (passing through I);

P = pinion ;

V = pinion shaft;

S = triangular plates, one solid with B and the other with V;

K = triangular plate with three arms passing at an angle through openings in the hollow armature shaft and encased in the motor body (figs. 554, right, and 555);

U = link-springs between K and T and between S and S;

T = triangular link-plate between I and K.

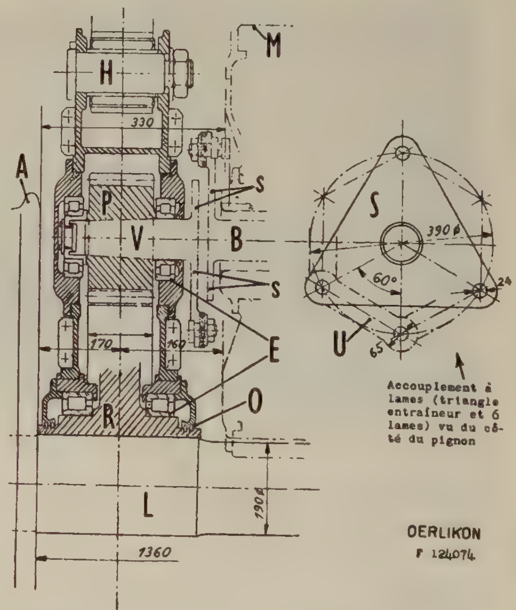


Fig. 552. — Mechanism of figure 551. Section through axle and motor (cardan shaft) centres. Right, the coupling plate with springs seen from the pinion side.
Same designations for the letters as in figure 551, and :

R = body of main gear wheel;

E = gearcase roller bearings;

H = gearcase support pivot;

O = ports in gearcase R.

by an articulated joint on the bogie frame (pivot H on fig. 552). The pinion also rotates in two roller bearings (upper E of fig. 552). As the motor is bolted to the bogie frame (the lugs can be seen under and to the left in fig. 553), it is wholly suspended.

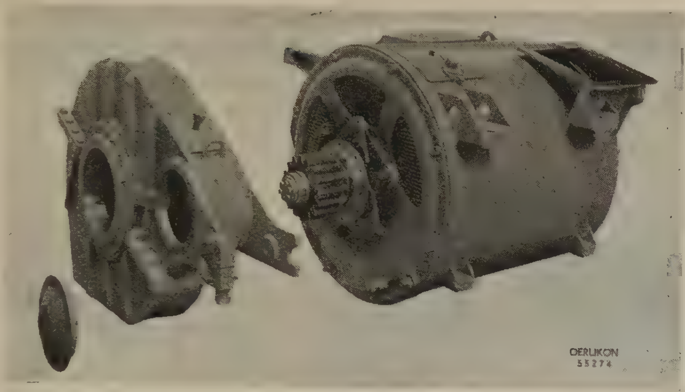


Fig. 553. — Traction motor (direct) (50 cycle), type 14-HW-750 (of the motor coach in figures 549 and 550) with pinion and gearcase for mechanism shown in figures 551 and 552. Behind the pinion are the plate and springs (fig. 552, right). In the front of the gearcase (left) are the bearings H (fig. 552).

Oerlikon 55274.

Fig. 554. — Component parts of the flexible transmission mechanism of figs. 551 to 553. The springs shown at the bottom of the illustration are mounted at the three angles of the triangular plates. The extreme right triangle, T of figure 551, is not reproduced in this illustration.

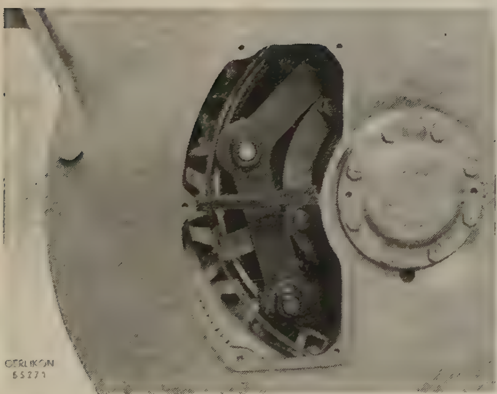


Fig. 555. — Part view of the motor in figure 553, with a cover plate removed, showing the springs. As shown in figure 551, the flexible transmission mechanism is, at the end opposite to pinion, encased in the motor body.

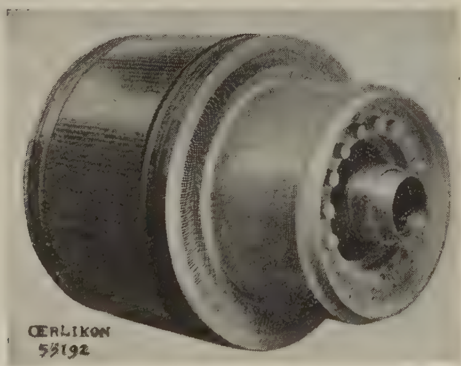


Fig. 556. — Armature of 50 cycle traction motor in figure 553. The hollow shaft for the passage of the cardan shaft will be noted, as well as the large commutating area required by the frequency.

With regard to item 2). — Figure 557 shows the new arrangement of the transmission used for the Zurich tramways (see figs. 250, 379 and 380).

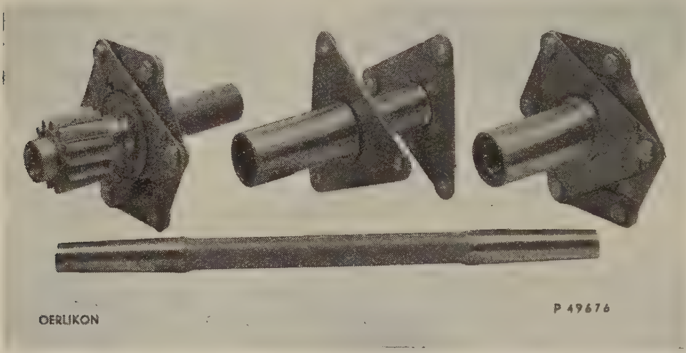


Fig. 557. — Component parts of the Oerlikon VI bilateral plate and spring mechanism of the 12 recent motor coaches of the Zürich VBZ. In contrast to figure 377 (original application) the triangular plates are located at both ends of the armature. The two triangular plates in the centre are the same as those at the right, concentric and linked by springs. At the bottom of the figure is the cardan shaft, to the left the pinion (cf. fig. 377 to 380 and 551 to 555).

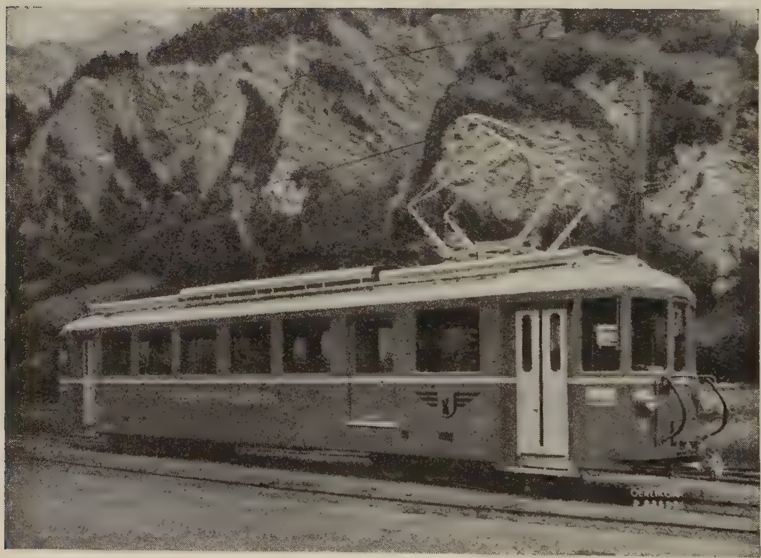


Fig. 558. — Motor coach No. 5 of the « Sernftalbahn », Schwanden to Elm line (fall of 438 m over 14 km [maximum gradient : 68 $^0/_{00}$]) in the Glaris canton of Switzerland.
The bogies of these motor coaches are those shown in fig. 381.

Photo Oerlikon P. 52552.

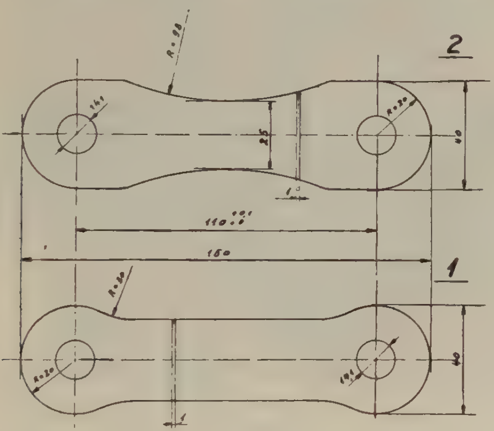
The two spring-linked triangular plates (at each end of the cardan shaft) are sleeved on the conical ends of the cardan shaft and there are therefore two concentric sleeves at the end opposite to the gears. The outer, hollow, stub forms part of the hollow armature shaft.

This bilateral spring transmission (fig. 557) has since 1949, been fitted successively to twelve tramway motor coaches of the Zurich VBZ. (Nos. 1376-1380, 1411-1415 [under construction in 1953]

and 1651-1652 (light motor coaches put into service in 1949) ([394]) as well as to five motor coaches for the secondary lines operated by the VBZ of the Forch Railway (Forchbahn, FB), Nos. 9 and 10, Zurich south-east suburban service, and the Sernf Valley (Sernftalbahn STB) Glaris canton, Nos. 5 to 7 (fig. 558). The driving bogies of these five motor coaches were shown in figure 381.

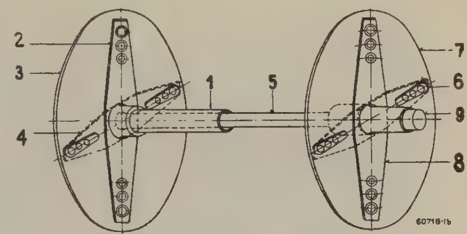
All these motor coaches of the VBZ, FB and STB have mechanical parts built by the SWS Works at Schlieren-Zurich, and electrical equipment by Oerlikon.

The Oerlikon VI plate and spring mechanism has several of the advantages listed before for the Secheron IV mechanism with leaf springs. The main difference rests in the fact that instead of two driving arms arranged at right angles (Secheron)



Plan VBZ ZW. 4082.

Fig. 559. — Shape of springs for Oerlikon VI cardan and spring transmission; above, in 2, the new form at the bottom, in I, the earlier type.



Plan BBC.

Fig. 560. — Diagrammatic representation of Brown-Boveri disc and cardan transmission (see figs. 245 and 246, and text of p. 192, *Vol. II*), *Congress Bulletin*, Nov. 1948.

1 = End of hollow shaft;
2 = Driver on the end of 1;
3 = Primary flexible disc;
4 = Driver on shaft 5;
5 = Inner torsion shaft of motor armature shaft;
6 = Driver pressed on shaft 5;
7 = Secondary flexible disc;
8 = Secondary driver;
9 = Pinion shaft.

([394]) The thirty VBZ tramway motor coaches, Nos. 1381 to 1410, are fitted with the cardan shaft and unilateral leaf spring coupling as in fig. 377, but are to be successively converted to the bilateral spring transmission and modified as described in the text. This corrects and amplifies what was stated on p. 299 of *Vol. II* (right-hand column) and the key to fig. 379. The two motor coaches Nos. 1381 and 1382 were under general overhaul at the end of 1953, after 249 000 and 271 000 km respectively; it was at this time that the first two motor coaches of the series were converted to bilateral spring transmission on the armature as in fig. 557.

To summarise the various transmission mechanisms of VBZ high-capacity motor coaches, Nos. 1351-1370, semi-heavy type, have Oerlikon nose-suspended motors, plain bearings on the axle :

— Nos. 1371-1375, as Nos. 1501-1550 (light type), BBC disc transmission (Simplex bogies) (fig. 250-254);

— Nos. 1376-1380, as Nos. 1411-1415 and 1651-1652 (light type), Oerlikon VI transmission, bilateral with triangular plates and leaf springs;

— Nos. 1381-1410, Oerlikon VI transmission, plates and leaf springs (unitateral) (fig. 377).

there are the three angles of the triangular plates (K in fig. 551, also shown to the right of fig. 554) which are connected by pairs of leaf springs. There are, consequently, six, instead of four, in each transmission unit (at each end of the cardan shaft). Whilst the application in item 1) comprises a one-hour rating of nearly 450 HP per motor coach axle, the fitting in item 2) transmits a power of less than 100 HP per driving axle.

It may also be noted that the shape of the springs has been redesigned and has resulted in a large reduction in the number of breakages; figure 559 shows the new and old form of these springs. Moreover, the provision of new SKF oil presses in the VBZ workshops, allowing easier and in particular more rapid dismantling of pressed-on parts, has increased the accessibility of the transmission components.

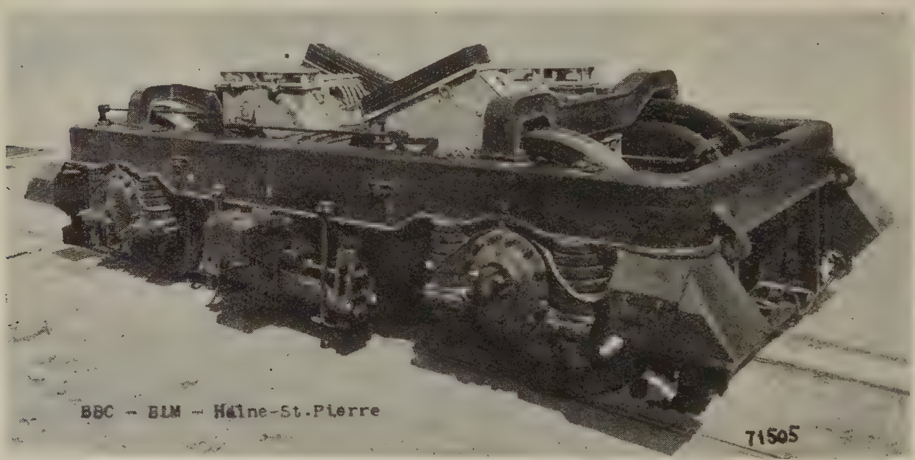


Photo BBC 71505.

Fig. 561. — Bogie of BB electric locomotives, type 121, Nos. .001 to .003, of the Belgian SNCB, shown in figure 249 (dimensioned sketch) and 212*b* (machine 121001 in service). These bogies were built by the Forges, Usines et Fonderies of Haine-Saint-Pierre, Belgium, under SLM-Winterthur license. Brown Boveri disc transmission in the armature centre (cf. figs. 247, 367 and 567).

We now pass to the *flexible steel disc transmission by Brown-Boveri* (395).

The mechanism has already been described in detail and we will show, in figure 560, only a diagrammatic representation of figures 245 and 246 and enumerate as nearly as possible in order of

(395) See *Vol. II*, pp. 185 to 199 and 289-290 (fig. 239 to 254) (*Congress Bulletin*, Nov. 1948 and January 1950).

introduction — a certain number of new applications, viz :

a) for heavy duty locomotives;

b) on motor coaches for main line railways (or for important secondary lines, metropolitan railways, etc.);

c) for tramway type motor coaches.

a) *Locomotives* (all for 1435 mm standard gauge).

1) *Belgium*. — Three B_0B_0 locomotives, series 121, Nos. 001 to 003, for 3 kV D.C., of the Belgian National Railways «B» (CFM-BSM or SNCB)

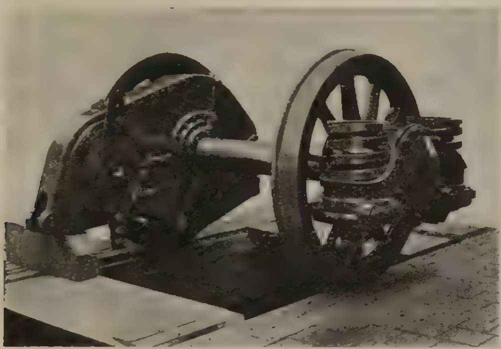
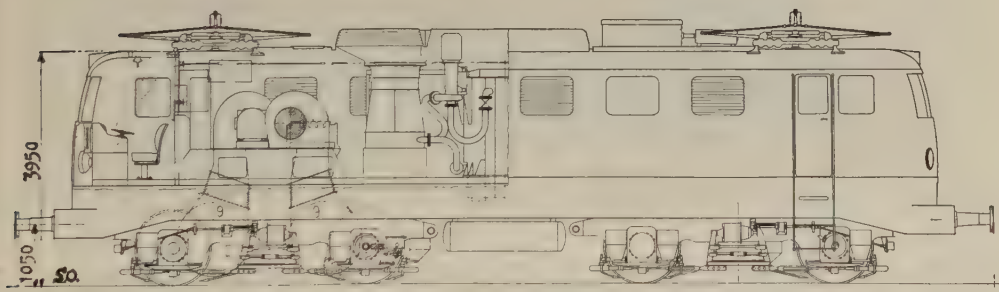


Fig. 562. — Driving axle, with boxes and bearing springs, of the BLS, series 251 locomotives, showing the gearcase and transmission arms, pinion side. The pivot at the left is carried by the suspension link.

Photo SLM (Cliché E. B

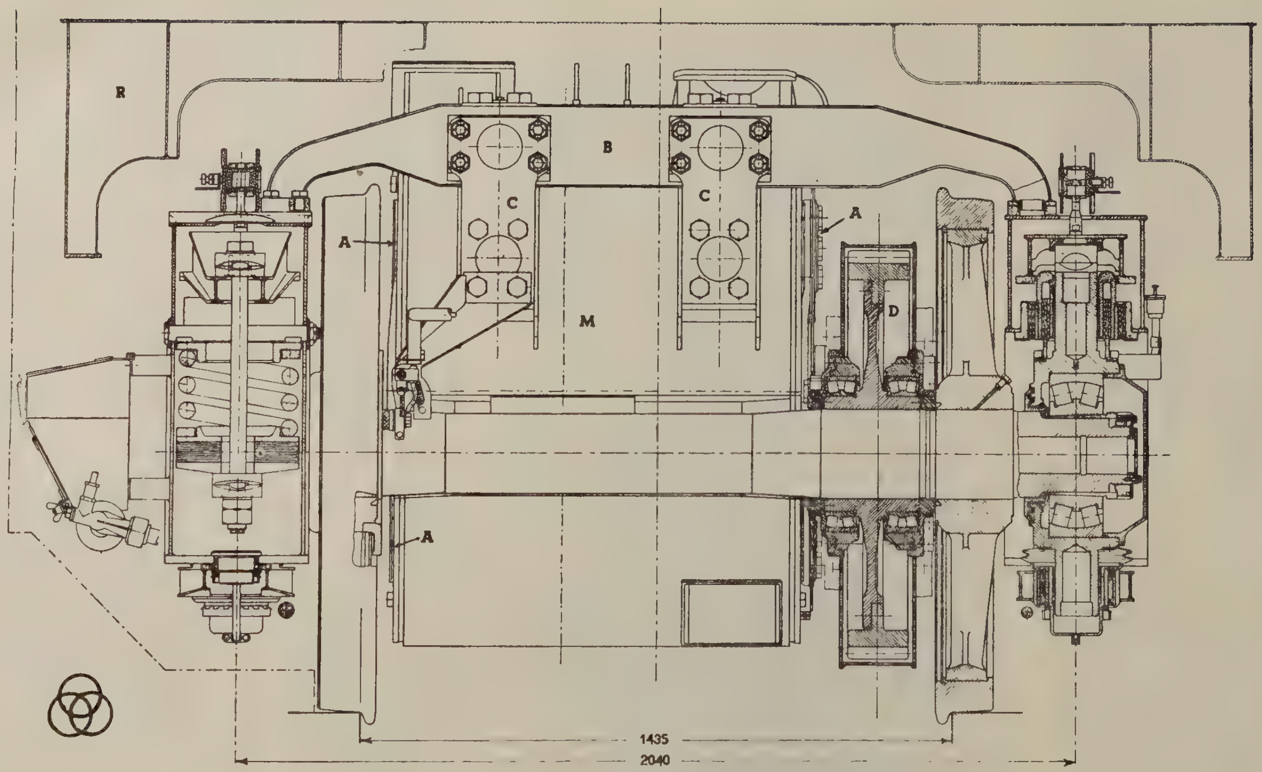


Plan BBC-Mannheim K. 251.359

Fig. 563. — Vertical section and elevation of the prototype $B_0'B_0'$, locomotive, class E. 10, No. 002 of the German Federal DB.

9 = traction motors with Brown-Boveri disc drive;
Mechanical parts constructed by Krupp of Essen (see fig. 564).
The two bogies are similar, their main dimensions are :

length overall : 16 650 mm;
bogie wheelbase : 3 300 mm;
total wheelbase : 11,3 m;
distance between pivots : 8.0 m.
(Cf. fig. 478, 538 and 541).



Plan KRUPP.

Fig. 564. — Elevation of one of the axles of the machine in figure 563, with part sections through the vertical centre line of the axle.
M = traction motor;
A = flexible disc and driving arms of the transmission mechanism;
B = traction motor carrier;
C = fixing for motor M to bar B;
right : section through axlebox with damper guide and silentblocs;
left : section through one of the axle bearing springs, on rubber pad.

put into service in 1949 ([396]) which were noted at the time of their construction ([397]) and illustrated in figures 249 and 212*b*. Figure 561 shows one of the bogies. The manufacturers of the bogies (under SLM license) and the mechanical parts are the Forges, Usines

overall length . . . . . . m		16.3
bogie wheelbase . . . . . m		3.6
distance between bogie centres . . . . m		8.0
wheel diameter (new). . mm		1 350
height of roof . . . . . . m		3.8

Block BBC-Mannheim.

Fig. 565. — DB locomotive No. E 10.002 (figs. 563 and 564) on a line in the Bavarian Alps.

et Fonderies of Haine-Saint-Pierre (Belgium). Electrical equipment is by Brown-Boveri. The dimensions in figure 249 (which remain appreciably the same — see fig. 212*b*) are as follows :

The bogies are linked by sprung guide rods [(fig. 6 of note ([396])].

The one-hour rating at rail of these machines is 2 800 HP at 51 km/h corresponding to a tractive effort of

([396]) See *Trains*, Brussels, Oct., 1949 « BB electric locomotives, 130 km/h (3rd series), type 121 locomotives », pp. 25-29, 7 fig., P. GHILAIN, O. GHINS, F. BAEYENS, H. VERBEECK.

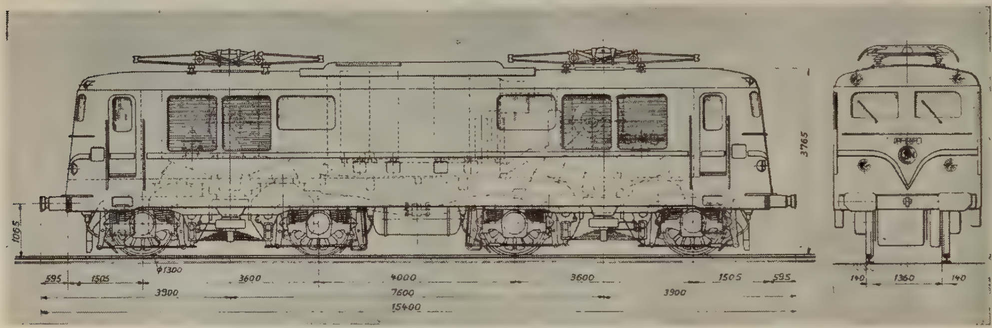
([397]) See preliminary sketch, fig. 249, and details on pp. 195 and 196 of *Vol. II.*

15 tons (about 20 tons maximum in starting). Weights are as follows :

mechanical parts.	t	43.5
electrical equipment . . .	t	39.5
total in service (approx.). .	t	83.5

No difficulties have been experienced in service.

is of particularly robust construction, is carried at one end by the axle (through two roller bearings, on the hub of the large gear wheel) and at the opposite end is hung from the bogie middle-bearer by a link with limited degree of freedom on the small pivot at the extreme left of the illustration. Because of this arrange-



Plan BBC.

Fig. 566. — Elevation and front view, with dimensions, of the B_0B_0 electric locomotives Nos. 9001 and 9002 of the French SNCF, 1953, with Brown Boveri disc transmission. Bottom right, the discs at both sides of the traction motor, between the wheels.

2) *Switzerland.* — Two single-phase locomotives, 15 kV 16 $^2/_3$ cycles, of the Bernese Alps (BLS) Railway (Lotschberg), Nos. 255 and 256 (series 251, class Ae $^4/_4$, see figures 244 to 248 and 366 to 368) similar to the four earlier ones put into service between 1944 and 1951 (for particulars, see p. 189, Vol. II) ([398]).

Figure 562 shows a driving axle of the BLS locomotives Nos. 255 and 256 (series Ae $^4/_4$, 251) with the transmission group. This gearcase, which

ment, the vertical movement of the pinion (to which the double arm seen on the left is fixed by means of the 2 × 3 bolts of the transmission disc) is only about half that of the driving axle (cf. figs. 245 to 247, also 66*a*, 66*b*, 518*d* and 521*a* (C) and 553 for similar arrangements).

3) *Germany.* — A prototype $B_0'B_0'$ locomotive, series E 10, No. 002 of the German Federal Railways DB, single phase, 15 kV, 16 $^2/_3$ cycles, put into service early in 1953. Figure 563 shows a

([398]) See E.B., July, 1953, pp. 162-170, fig. 1-18, part B of article « Modern Swiss single phase, A.C., locomotives », A.E. MÜLLER, G. BORGEAUD.

diagram of it, with part section and the main dimensions are given. Figure 564 shows a plan of one axle and figure 565 the locomotive in service. (399) The builders are the KRUPP Locomotive Works, Essen, for mechanical parts and BBC-Mannheim for the electrical equipment (high-tension voltage control).

4) *France.* — Two prototype B_0B_0 locomotives Nos. 9001 and 9002 of the French SNCF, 1500 V D.C., built in Switzerland and put into service in the summer of 1953 (400). Figure 566 is a front and side elevation. Figure 567 shows a bogie, photographed from above, fitted with one of the two motors and clearly illustrates the

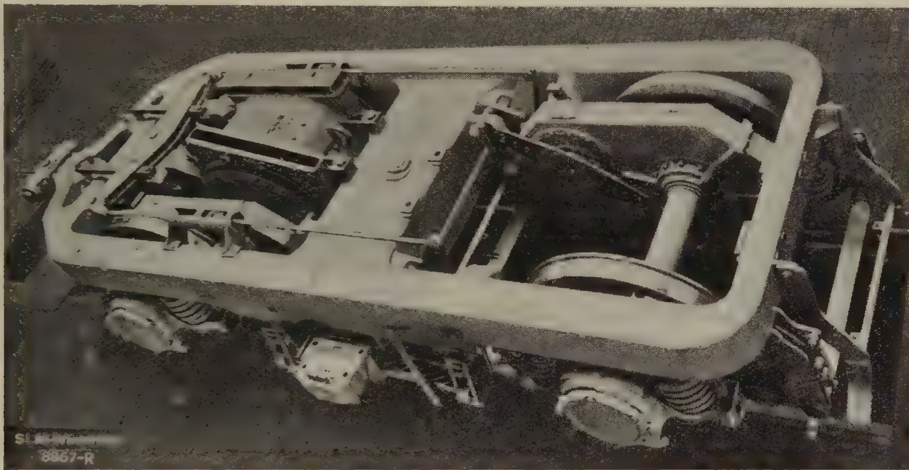


Fig. 567. — Driving bogie of SNCF locomotives 9001 and 9002 (fig. 566). The right-hand motor has been removed and the disc driver can be seen in front of the gearcase. Left, the bogie return arrangement. Isothermos boxes (cf. fig. 367).

(399) See publication mentioned in note (388). — See also E.B. April, 1954, « New $B_0'B_0'$ electric locomotives of the Bundesbahn », 26 p., 47 fig. and diagrams, E. KILB, H.D. KÜGLER, H. HERMANN, H. KÄFER, H. v. BEZOLD, W. HEGNAUER. These six authors covers, respectively, development (*a*), electrical equipment (*b*), mechanical parts (*c*), development of the Brown-Boveri disc mechanism (*d*), pendulum suspension of the axles (*e*) and a comparison between the high and low-voltage control systems for electric locomotives (*f*).

With regard to the subject of this article (axle drive) see figs. : 11, 13 and 14 of (*b*); 1, 8, 9, 10 and 11 of (*c*); 1 to 10 of (*d*); 1 and 2 of (*e*).

(400) See A.F.A.C., No. 167, Mar.-Apl., 1951, in « Problems of BB locomotives at high-speeds »; « BB 9001-9002 », pp. 27 to 31, general plan and diagram, A. GACHE, D. CAIRE.

See also R.G.C.F., Dec. 1953, « BB 9001-9002 electric locomotives of the SNCF », 16 p., 25 fig. diagrams and sketch, W. HEFTI and A. FEDDERSEN.

transmission mechanism. These two machines have a one-hour rating of 4060 HP (at the armature shaft with a speed of 76.5 km [47 miles]/h, and 1 350 V) and can develop a maximum speed in service of 160 km (100 miles)/h.

The builders are the SLM locomotive works, Winterthur, for the mechanical parts and Brown-Boveri, Baden (Switzerland) for the electrical equipment. The tare of these two machines is 77 tons.

Locomotive No. 9002 has been ballasted since it was put into service to increase its weight to a specified 80 tons; locomotive No. 9001 is to be dealt with similarly. The behaviour of these two locomotives at high speeds is unquestionably good, although the running may be rather heavy because of the omission of rubber mountings.

b) *Motor coaches for main*, secondary and metropolitan lines. Four important applications in *Switzerland* and one in *Spain*.

5) *Nineteen* of the thirty-one motor coaches, series 841, class $CFe^4/_4$ of the Swiss Federal Railways, SBB-CFF-FFS, standard gauge, single phase, 15 kV 16 2/3 cycles (mentioned under item *b* of the Secheron IV), Nos. 845 to 863 [see figs. 531 and 532 and note (385)].

6) *Two twin motor coach sets* of a completely new type (class $RBe\,^4/_8$), Nos. 661 and 662 (401) also of the CFF, put into service in the summer of 1953, comprising two driving bogies in the centre and two carrying bogies at the ends. Figures 568 and 569 show them in service and give a dimensioned sketch. The main details are as follows :

Photo CFF P. 421.

Fig. 568. — Express twin set, No. 661, class $RBe^4/_8$, of the Swiss Federal Railways, SBB-CFF-FFS, outside the Berne depot. Put into service, 1953.

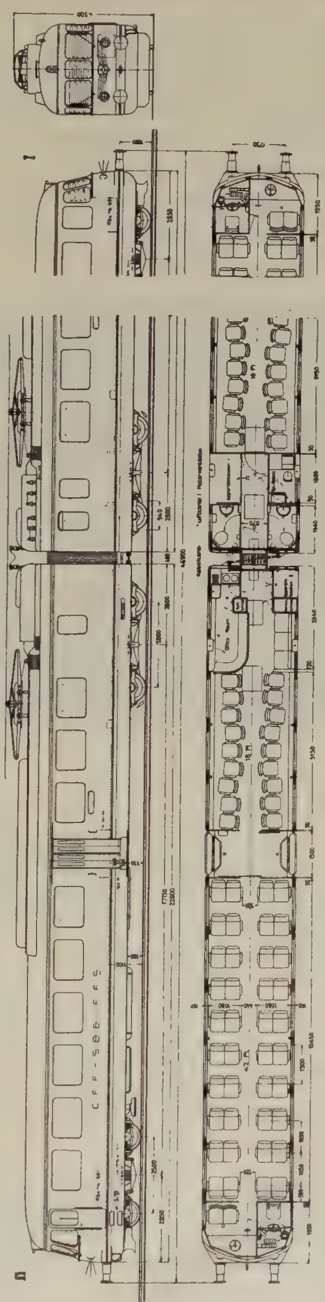
overall length	m	46.9
weight of mechanical part	t	66
weight of electrical equipment	t	21
tare	t	87
pay load (passengers) . .	t	10
loaded weight (on 8 axles).	t	97
number of seats		123
one-hour rating (4 motors)	HP	1400
maximum speed in service :		125 km (77 miles)/h

(401) See *Bulletin des CFF*, Berne, No. 9, 1953, pp. 132-134, « New double motor coaches for excursion services », 6 fig. (French, German and Italian texts).

See also A.F.A.C., No. 186, May-June, 1954, « French and Swiss Railways », fig. on pp. 59 (top) and 60, D. CAIRE.

The builders are : mechanical parts SWS Works, Schlieren-Zurich; electrical equipment, Brown-Boveri and Secheron.

A year or two of service will show whether this motor set, which has been specially designed for tourist traffic (group excursions, etc), fulfils the demand. The sets are painted red, like the earlier « Red Arrows » (figs. 151-152, 157-158 and 134-135). With regard to the two items 5) and 6), standard gauge motor coaches, the Motive Power and Workshops Department of the CFF state that when the single phase traction motors are running under heavy load, the transmission sets up vibration of the body and bogie frames, that these vibrations are not caused by the type of transmission, however, but by the pulsation of the AC motors, which creates a double harmonic. The CFF is at present considering methods of eliminating this vibration and the problem will be referred to again later. The author of this article considers that in certain cases it may be desirable to introduce a resilient rim for the main gear wheel of the transmission in the gear case, or better still, a resilient rubber transmission; tests could also be made, in cases of this kind, by fitting resilient wheels (with rubber, see fig. 238*a*, 255, 371, 403 to 409, 412, 414), but it is difficult to say if this would be sufficient as such damping would be primarily between the axle and the



Plan SWS 14622d.

Fig. 569. — Dimensioned sketch (shortened) of sets 661 and 662, RBe$^4/_8$, CFF, of figure 568, Brown-Boveri disc drive. The two centre bogies are driving, the end ones carrying. The wheels are 940 and 900 mm diameter respectively. Apart from the articulation, the two coaches of the set are symmetrical. The double seats of the leading compartments are reversible, the centre compartment chairs are removable. The loads per axle (tare) are 14.5 t for the driving axles and 7.5 t for the carrying axles (loaded, 15.5 and 8.8 t).

track, and would reduce the unsprung weight.

7) *Three* bogie motor coaches, Nos. 40 (formerly No. 35, converted), 41 and 42, of the Berne-Worb Railway (Vereinigte Bern-Worb Bahnen) VBW, 1 metre gauge, 800 V D.C. (length of system 24 km). Figure 570 shows a train on the line. These three motor coaches, class Ce$^{4}/_{4}$, were put into service in 1930-52, 1946 and 1948 respectively (402). Builders SSW-BBC (Simplex bogies).

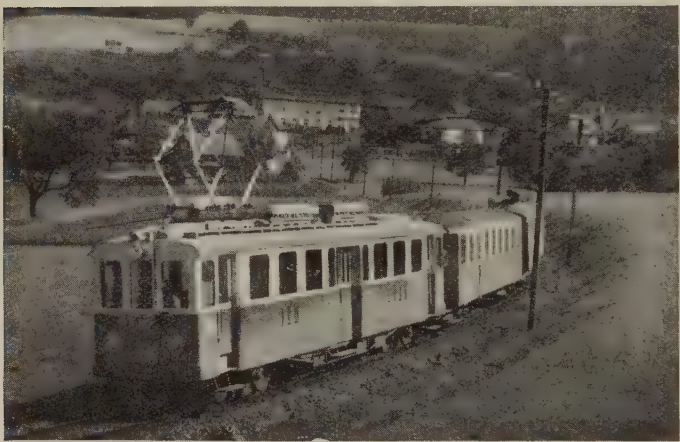


Fig. 570. — Ce$^{4}/_{4}$ motor coach No. 40 (35) of the metre gauge system Berne-Worb, VBW, hauling a train on a gradient in the direction of Bale.

Photo BBC 65983.

8) *Two* bogie motor coaches, class Ce$^{4}/_{4}$, Nos. 7 and 8 and one spare bogie of the Aarau-Beromunster «Wynentalbahn » (Argovie canton, Switzerland) which were put into sercice in 1954. Metre gauge, 750 V D.C. Builders, mechanical parts SWS; electrical equipment BBC (402).

9) *Eleven* motor coaches, 4 driving axles, Nos. 360 to 370 (series 300, sets composed of one motor coach and one trailer) of the F.C. Metropolitano Transversal of *Barcelona* (403) (put into service in 1953-54), 1500 V D.C., third rail current supply, 1674 mm track gauge (Spanish wide gauge), 1-hour rating at pinion shaft 680 V at 34.5 km (21 miles)/h corresponding to a tractive effort of 5 tons at rail; maximum speed 55 km (34 miles)/h. Figures 571, 572 and 573 respectively show a dimensioned sketch of the sets (series 300), a view of a set on

(402) See *Brown-Boveri Mitteilungen* (also in French), Baden, No. 11-12, 1953, pp. 482-488, 5 fig. For the motor coaches under 8, same publication and pp. 488-492, fig. 6 to 10 (also referring to the Aarau-Schöftland, under the same operation), H. BERTSCHMANN.

(403) With regard to the Barcelona metropolitan lines, see E.T.T., No. 4-6, 1953, pp. 2-4 (fig. 2 refers to the «Transversals») and also, V. & T., Nos. 5 and 6, 1953, « Barcelona Underground Railways », 20 figs., F.W. HAMACHER.

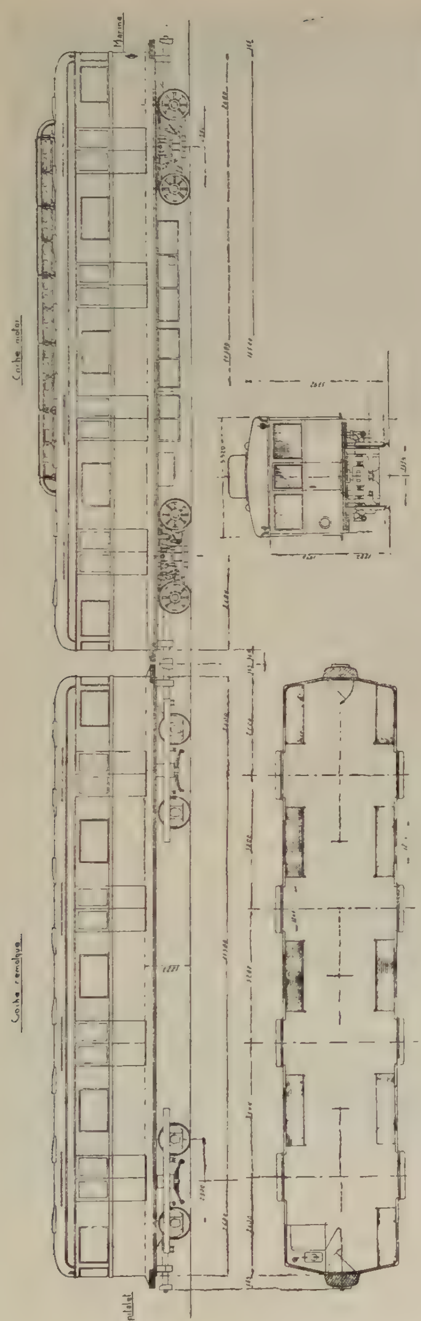


Fig. 571. — Dimensioned elevation, plan and front view of one of the 11 series 300 sets of the Metro-Transversal of Barcelona, the first of which was put into service in 1953, April.

Plan « Maquinista ».

a siding and a driving bogie. The tare of these motor coaches is 43.5 tons, of which about 24.5 tons is the body complete and 19 tons for the two bogies complete with motors. The two motors of each bogie (Simplex type) with a wheelbase of 2,3 m and a wheel diameter of 838 mm remain coupled in series and the motors must normally run at a tension varying between 1 300 and 1 600 V in the third rail. The capacity provided (seated and standing) is more than 300; average speed on level track for a 500 m run = 29.5 km (18 miles)/h. Gear reduction ratio = 1 : 5.46.

These motor coaches were built by the Maquinista Terrestre y Maritima of Barcelona, with Brown-Boveri electrical equipment.

10) *One* motor coach, class Z, No. 9052, for single-phase, 20 (25) kV, 50 cycles, direct motors (standard gauge) of the SNCF, put into service in 1953 on the Annecy line. This is one of the coaches of the same series as Z 9051, already described in connection with the Oerlikon leaf-spring mechanism, see figure 549 (404).

This motor coach is to serve for successive testing of various types of transmission (on the same single

(404) See *Brown-Boveri Mitteilungen*, Baden, No. 11-12, 1953, pp. 476-481, 11 fig. (particularly fig. 8), « Motor set Z 9052, SNCF, Brown-Boveri series-commutator motors for 50-cycle, single-phase A.C. », H. WEBER (German and French).

Fig. 572. — Set in figure 571, composed of motor coach No. 360 and trailer No. 337.

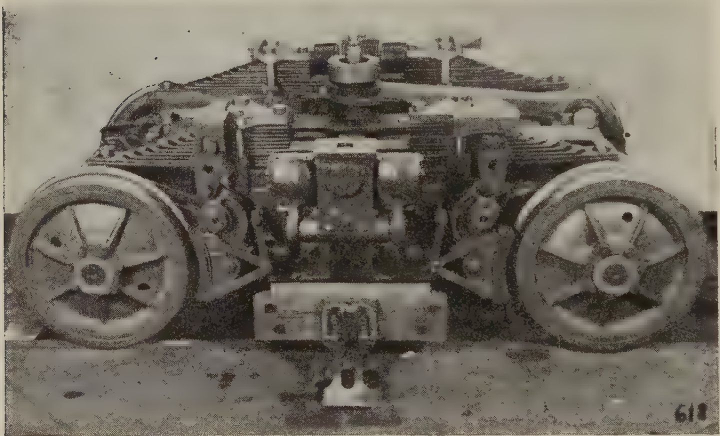


Fig. 573. — Driving bogie of a series 300 motor coach of the F.C.M.T. (fig. 571 and 572), «Simplex» type, without frame, fitted with two 170 HP motors (one-hour). Brown - Boveri flexible cardan and disc transmission. This shows silentblocs at all the important joints to reduce lubrification, wear or noise. SKF axleboxes. Air brakes by General Electrica Española. Cf. figure 251.

coach). One-hour rating at pinion shaft 1 680 HP at 56.4 km (35 miles)/h. Maximum speed 80 km (50 miles)/h.

c) *Tramway motor coaches.*

We have dealt with a certain number of applications to tramway vehicles in Switzerland, fitted with cardan shaft and disc transmissions ([405]) and we may add the following, 1949-50 :

11) *Zurich* Municipal Transport (a city which in 1953 reached, with its near surroundings, half-a-million inhabit-

([405]) See pp. 197-198 of *Vol. II*, fig. 250 to 254.

ants), « Verkehrsbetriebe der Stadt Zürich », VBZ, formerly St. St. Z., now has, taking into account those already mentioned and apart from spare bogies, a total of 55 motor coaches with BBC disc transmission, i.e. Nos. 1501 to 1550 and 1371 to 1375, put into service successively between 1941 and 1952. The builders are the same (SWS-BBC).

12) *Berne* (Swiss capital) municipal transport, « Städtische Verkehrsbetriebe Berne », SVB, put into service between 1947 and 1949, *fifteen* motor coaches Nos. 101 to 115, of the same type, built by SWS-MFO, similar to those in figures 250, 528-529 and 570. Hourly rating of one coach at pinion shaft, 260 HP. Maximum speed 50 km (31 miles)/h.

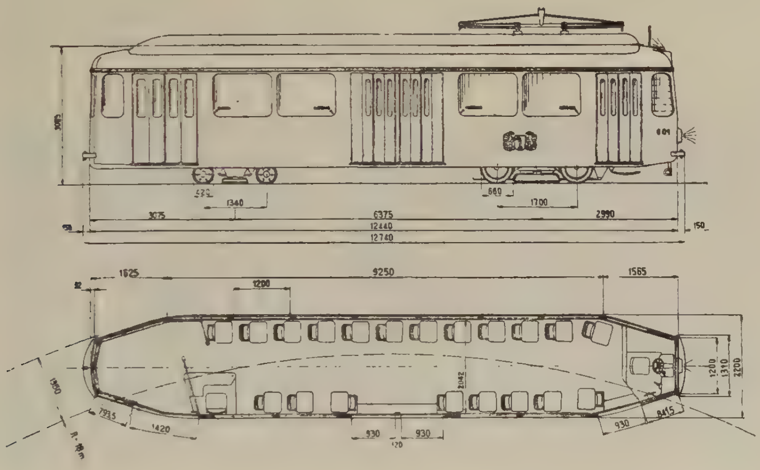


Fig. 574. — Dimensioned plan and elevation of $Ce^2/_4$ light motor coaches series 601, one driving bogie, cardan and disc transmission, with low-slung body, of the Bale BVB, 1952. Built by SWP.

Plan BBC 5-100169.

Photo BBC-77765.

Fig. 575. — BVB-Bale motor coach No. 602 of figure 574, in service. (Cf. fig. 250, 528-9, 542-3, 573.)

13) *Bale* (second largest city in Switzerland) municipal transport, « Basler-Verkehrs-Betriebe » BVB, 600 V D.C. put into service successively from 1947 to 1952, 52 motor coaches, $Ce^4/_4$, similar to those in figures 250 and 528, with BBC discs, Nos. 401 to 452, with several spare bogies (Simplex type); then in 1951-52, *three* ultra lightweight motor coaches with one driving bogie and one carrying bogie, class Ce $^2/_4$, Nos. 601 to 603 (see figs. 574 and 575) with a one-

a

b

Blocks V. & T.

Fig. 576. — New motor coaches and trailers, 1953, of the Vienna municipal transport, with disc transmission; *a*) the set; *b*) interior of one of the coaches.

Photo Westwaggon.

Fig. 577. — Set of three pairs of wheels (driving, guiding, driving) of the new, 1953-54 motor coaches of the Bonn-Bad Godesberg and Mehlem (Rhineland) Tramway. The guiding of the axles is by cardan rigging. The motors here are nose suspended (roller bearings).

hour rating of 2 × 65 HP (driving bogie), maximum speed 55 km/h [406]. For all these 55 motor coaches, the mechanical parts were supplied by Schlindler (SWP) Pratteln, Bale, and the electrical equipment by Brown-Boveri.

14) *Lucerne* municipal transport « Verkehrsbetriebe der Stadt Luzern» VBL, put into service in 1948, *ten* motor coaches, also of a similar type to those in figures 250 and 528, $Ce^4/_4$, for 600 V D.C., Nos. 101 to 110, one-hour power 220 HP at the pinion

(406) See *National-Zeitung*, Bale, No. 74, 14-2-52, « Ultra-lightweight tramway motor coaches of the Basler Verkehrs-Betriebe », 1 large page, 2 fig. (in German).

shaft at 35 km (21 miles)/h, maximum speed 60 km (37 miles)/h. The builders of the mechanical parts for the first six coaches are the Schindler-Waggon, SWP, Pratteln, Bale; the remaining four, the Hess Coachworks, Soleure; electrical equipment is by Brown-Boveri.

Items 11), 12), 13) and 14), which are all Swiss, thus refer to motor coaches for city tramways, one metre track gauge and $Ce^4/_4$ class (apart from the Bale 601 series). With regard to other countries, *Norway* and *Austria* may be noted, still in connection with city tramways, as under :

15) *Bergen* tramways (east coast of Norway) put into service from 1946 to 1949, *ten* bogie motor coaches for 600 V D.C., metre gauge, one-hour rating 200 HP at 32 km/h; maximum speed 60 km/h.

16) *Vienna* (Austrian capital) municipal transport « Wiener Stadtwerke Verkehrsbetriebe » have put into service since 1953, 19 bogie motor coaches, Nos. 101-119 for 600 V D.C. standard gauge one-hour rating 280 HP at 28 km/h; maximum speed 55 km/h. Figure 576 shows coach No. 101 with trailer No. 201 (*a*) and an interior view (*b*).

To conclude this chapter on cardan transmissions, mention may also be made of motor coaches (for tramway or secondary railway lines) with three axles, the central axle with small wheels serving only to guide the two outer driving axles located under the body with pivots and rings allowing them to rotate in accordance with the degree of curvature and give good running on straight track. In order that curves may be correctly traversed, parabolic transitions are desirable, otherwise there is, according to the amount of tyre play, some slight strain when one of the driving axles and the guiding axle are still on straight track, whilst the other driving axle is still on the curve.

Some examples of such fittings have already been mentioned in *Volume I* (1933, figs. 195 and 196, p. 96).

Some progressive applications were undertaken over a period of years by the Winterthur (Swiss) municipal transport (since converted to trolleybus working), on the Saarbruck (Saar) tramways and on those of Luxemburg. More or less important series have recently been put into service on the Munich (Bavaria) Stadtwerke Munchen Verkehrsbetriebe, the Amsterdam (Holland) Gemeenetram and on the Bonn-Mehlem (Rhineland) local railway. Figure 577 shows the most recent set of wheels for one of the Bonn-Mehlem motor coaches, manufactured by WESTWAGGON of Cologne under license from the SLM-Winterthur Locomotive Works in Switzerland. We will return to some of these applications in the supplement to *Volume III* (1954) and pass now to the last chapter VII, Rack railways.

(to be continued.)

[656 .211 .5 (436)]

The Central Enquiry Office of the Austrian Federal Railways in Vienna,

by M. J. FRISCHAUF, Ing. dipl.

SUMMARY

When the timetables were altered in May 1952, the Austrian Federal Railways opened a Central Enquiry Office to give information about the train services. In the following article the reasons which led to the organisation of this enquiry office are reported, together with its technical equipment and the experience obtained since it was opened.

1. General data about the information given to passengers.

Undertakings concerned with the transport of passengers put at the disposal of the users of their services — if only for publicity reasons — every facility in the form of indicators and posters giving the timetables, thus enabling the public to determine the best route, cost of tickets, etc. for themselves.

Occasional travellers find out what they want to know personally or by telephone from an enquiry office organised for this purpose by the transport undertakings.

Such enquiry offices also usually have a part to play when any modifications are made to the indicators and posted up timetables, for example if the times are changed, if new trains are introduced, or additional trains put into service, fares altered, etc.

Such an enquiry office is particularly active in the case of transport undertakings who have to carry some thousands or tens of thousand passengers a day to or from a given town, i.e. the railway system. The enquiry offices are constantly being called upon, but the number of requests for information varies considerably and depends upon the most diverse factors.

As a general rule such enquiry offices are in stations with heavy passenger traffic or close by them, so that passengers leaving or arriving at that station can get the information they need verbally. In large towns with several stations, Vienna for example, such a method makes it necessary to have a considerable number of enquiry offices.

Observations made on the enquiry services have confirmed those made in the case of telephone messages, namely that the peak periods do not coincide at all in the enquiry offices.

On the other hand, they also showed that the figures relating to information given verbally or by telephone at the same office varied considerably as regards the time and amount, and that the peak hours for these two types of information are widely separated, as was only to be expected in view of the time lapse between making preparations for a journey and the departure or break of such journey.

In Vienna, requests for information by telephone during recent years have increased far more than verbal requests. This phenomenon is due, above all, to the fact that the war led to the destruction of a great part of the telephone system and telephone installations, and at first subscribers were only reconnected very slowly. During this period the supplying of information by telephone was only of secondary importance. It was only when the reconstruction of the telephone services had made considerable progress that the telephone traffic of the enquiry office also increased. The single lines originally provided at the six stations of Vienna and connected up with the general telephone system were soon in such frequent demand that calls could not be answered immediately which led to increasing complaints from the travelling public. Trials with an installation of several lines grouped under the same number in one of the stations showed this was no solution to the problem. If such a method were to be made general, a very great number of lines would have been needed to serve each station, as well as a large staff.

From the knowledge obtained regarding telephone technique it appeared that a better user of the lines could be obtained by grouping them together, and by dealing with all the traffic carried by this group of lines in a central office.

The measures to be taken in a central office of this sort to meet requirements satisfactorily had to answer the following conditions.

2. Principles.

a) The caller using the public telephone network should not come up against an unduly large proportion of number engaged signals.

b) The waiting time (from the first ring to the time the enquiry staff take the call) should be reduced to the minimum;

c) The information required must be given quickly, and enquiries that have to be made at other offices should take the minimum time to get through;

d) To increase the output, it is necessary to reduce the physical fatigue of the enquiry staff to the utmost possible;

e) The installation must allow for the possibility of replacing verbal enquiries in the stations by information supplied by telephone.

Translated into telecommunication language, this amounts to saying that in the technical study and plans as a whole the following points must be borne in mind :

a') The chief group of lines *(Amtsleitungen)* must be calculated in such a way that any loss of time at the telephone centre must remain within acceptable limits at peak hours. (As it was not possible to make any actual trials when studying the installation, it was provisionally assumed that a complete group of ten lines would be sufficient.)

b') So that the waiting time is not unduly prolonged, even at peak hours, there must be a sufficient number of employees and enquiries must be dealt with in order of arrival.

c') The supervisor must also be kept informed of the amount of traffic, so that the number of employees available for calls corresponds to the amount of traffic.

d') The operation of the technical

installations must be as simple as possible so that the employee dealing with enquiries does not have to waste too much time on this. (The documents should be properly filed and easy of access.)

e') The difficulties involved in using the ordinary type of telephone in which the receiver has to be held in the hand should be avoided by the installation of loud-speaker telephones *(Freisprechanlage)*.

f') The lighting and ventilation of the office should be carefully designed.

g') Distracting noises from adjacent offices should be well damped out.

h') It must be possible to increase the number of lines when necessary.

In addition the installation should be able to keep records of certain amounts of traffic.

3. Arrangement of the Central Enquiry Office (ZZA).

The realisation of the conditions laid down was first of all a problem of the necessary liaisons which was solved by making use of the devices normally used in telecommunication technique, after which the problem of construction and organisation arose.

We will now consider these points in detail.

3.1 *Basic diagram* (fig. 1).

For each of the x lines to the enquiry office A1 .... Ax there is a preselector $AW_{(1-x)}$ and a set of relays $ARS_{(1-x)}$. Each preselector has y outlets coupled in parallel and ending in y sets of connecting relays $VRS_{(1-y)}$.

To these connecting relays $VRS_{(1-y)}$ also come the y outlets coupled in parallel of z call selectors $PW_{(1-z)}$ provided, with the corresponding sets of relays $PRS_{(1-z)}$ for each of the z lines.

The y outlets of a single classifying selector *(Reinhungswähler)* RW for the whole installation also lead to the y groups of connecting relays. The group of relays corresponding to the classifying selector RW is RRS.

The recording equipment SpK *(Sprachkonserve)* connected to the relays $VRS_{(1-y)}$ also serves the whole installation.

Figure 1 also shows that for each prin-

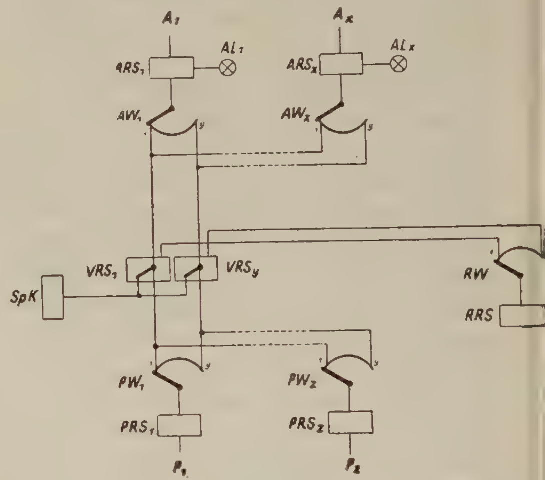


Fig. 1. — Basic diagram illustrating the principles involved.

A_1 .... Ax	Principal lines 1 to x
ARS_1...... $ARSx$	Groups of relays for principal lines 1 to x
AL_1 ...... ALx	Call lamps 1 to x
AW_1 ..... AWx	Preselectors 1 to x
VRS_1 ..... $VRSy$	Groups of relays for branches 1 to y
PW_1....... PWz	Selector at operating desks 1 to z
PRS_1...... $PRSz$	Groups of relays at operating desks 1 to z
P_1 .... Pz	Operating desks 1 to z
RW	Classifying selector
RRS	Group of relays for classifying selector
SpK	Recording device (Sprachkonserve).

cipal line there is a lamp $AL_{(1-x)}$ which, as we will show later on, has to fulfil several functions.

3.2 *Functioning of the installation.*

We will take it that the selectors used in the installation are all rotary selectors and that their arms move in the direction 1 — y.

The classifying selector RW has to mark in their order of succession the steps from 1 to y for the preselectors. At a given moment it will be in the position i, for example.

A call coming in on the principal line k will put AWk into the position i and affect the group of connecting relays VRS_1. The group of relays ARS_k will light up the valve AL_k first of all as a call sign. The group of relays VRS_1 will give communication with the centre and the recorder SpK answers the caller: « Enquiry office — one minute please ».

The classification selector RW has thus fulfilled its role of classifying the call and returns to the position $i + 1$.

If a call comes in on another principal line n, AW_n will go into the position $i + 1$. The operations we have just described will be repeated for this call and the selector RW will then move to the position $i + 2$.

If a call classified in this way has not been dealt with at the end of a predetermined period, a thermic relay inserted in the group of relays ARS will then cause commutation of the lamp AL through a switch. This lamp then burns very brightly which means that the call has already been kept waiting for a certain period.

When the listening in switch of any of the operators desks is pressed, for example desk j, the corresponding selector PW_j explores the contacts till it reaches the first call classified in order 1 — y (therefore in this case as far as the position i) where it stops; the recorder SpK is cut out of circuit and the caller waiting on the line k is connected to the desk j. At the same time, the lamp AL_k is supplied with current at a lower voltage and gives a weaker light which is the signal for « occupied ».

When communication has been established in this way, it lasts until the caller has finished his conversation and replaces the receiver or the enquiry employee presses the cut off switch at his desk. The lamp AL then goes out and the principal line can then be used for a new call.

This arrangement guarantees that calls will be dealt with in the order they are received and none of those waiting to make a call will be favoured at the expense of anyone else, while the number of desks in use remains constant. If at a given moment, all the desks are not engaged and the increasing traffic makes it necessary to use an additional one, it may happen — in view of the fact that the selector of this desk may be in any one of the y positions possible — that there is a change in the order of the calls already waiting if the selector should be in the same position as one of these calls. But this irregularity, which the callers will not know anything about, will soon eliminate itself.

3.3. *Other telecommunication installations.*

To assure the output of the installations, and above all to give the enquiry staff

every imaginable facility, so that they can answer all enquiries quickly and completely, the documents and desks have been arranged on rational lines and a whole series of supplementary telecommunication installations set up.

In view of the fact that ordinary telephones, as used in all the telephone offices, need one hand all the time, and that the headphone type of telephone with chest-microphone, even in its most up-to-date form, is tiresome for the operator, each desk has been equipped with a *loud-speaker telephone* (microphone and loud-speaker). The amplifier for the incoming and outgoing calls is fitted at the desk itself, the electrodynamic loud-speaker on the desk and the dynamic microphone on a bracket, so that there can be no acoustic reaction between the loud-speaker and microphone. The distance between these two pieces of equipment is about 15 cm as a rule.

To replace the loud-speaker telephone installation an ordinary telephone is also provided which puts the loud-speaker telephone out of circuit when the receiver is taken off.

We will return later on to the need to insulate the desks from each other.

In view of the arrangement of the installation (cf. 3.2) all enquiries must be answered from no matter which desk. It sometimes happens however that to answer some particular enquiry calls for specialised knowledge, for example an enquiry in a foreign language, etc. For this purpose, there are certain special employees who when not dealing with enquiries of this kind, have to answer any enquiries like their colleagues. These employees however have not to be tied down to any particular desks, so that an enquiry of this kind can be transmitted to any desk.

With this object in view a sort of *line selector system* with 10 members has been installed. Each of the buttons of this selection installation corresponds to a given meaning, for example, enquiries in French, in English, or travel abroad, etc.

By pressing the corresponding button a special lamp is lit up at each of the desks. The employee appointed to deal with such enquiries then presses a special receiver button on his desk and takes over the call, which frees the other desks for other calls.

As such enquiries are relatively rare, there is no need for the simultaneous transfer of two enquiries, which has simplified the installation.

The centralisation of enquiries also made it necessary to have direct communication with the different stations in Vienna if only to allow employees to check certain information at any time. For this purpose a small central office has been set up allowing of five conversations at one and the same time, and the desks and different stations are connected to this. The employee can connect up with this installation by means of a special switch and select the station he wants by means of a call disc. If the line is occupied, he will automatically be connected up as soon as the conversation ends. Communications of this kind are cut out by means of a special cut-out switch by the enquiry staff.

Delays in the running of the trains and other information affecting passengers are reported as they occur by the stations to the head of the Enquiry Office by means

of a special *multiple telephone;* the head of the Enquiry Office reports these communications to his employees as we will describe later on.

When the substitution of page teleprinters for the roll teleprinters now being carried out on the Austrian Federal Railways is completed, such communications will be sent to the head of the Enquiry Offices by *teleprinter*.

For this reason, the top of the desk has been divided into three panels.

In the left panel, which can be lifted up around a hinge on the upper side is fitted the equipment for working the installation. In the top row there are the buttons for the line selectors (cf. 3.3) and above them the corresponding lamps which light up the indications. Below, from right to left, are the buttons for

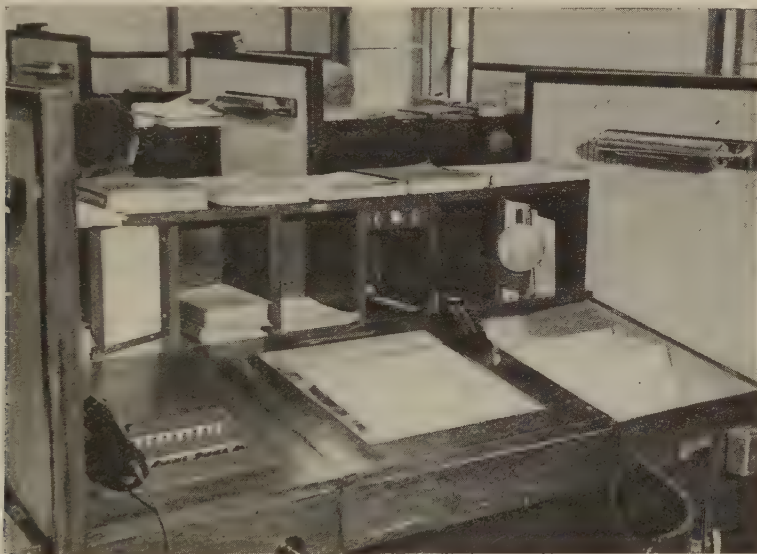


Fig. 2. — Incoming desk, seen from the front.

answering and cutting off calls, the reception buttons, the branch switch and the cut out switch. As figure 2 shows the spare telephone is also kept here.

3.4. *The operator desks* (see fig. 2).

In designing the desks, the guiding principle was that employees must concentrate as far as possible on supplying actual information and they should not be distracted by supplementary work such as looking up timetables, etc. Equipment of secondary importance as regards supplying information must therefore be placed outside the field of work properly speaking.

In the centre portion, the through coaches on long distance trains with their chief stopping stations are shown on an endless band which moves under a glass panel (fig. 3 shows a section of this band). The band is turned by means of a flywheel which projects a little from the level of

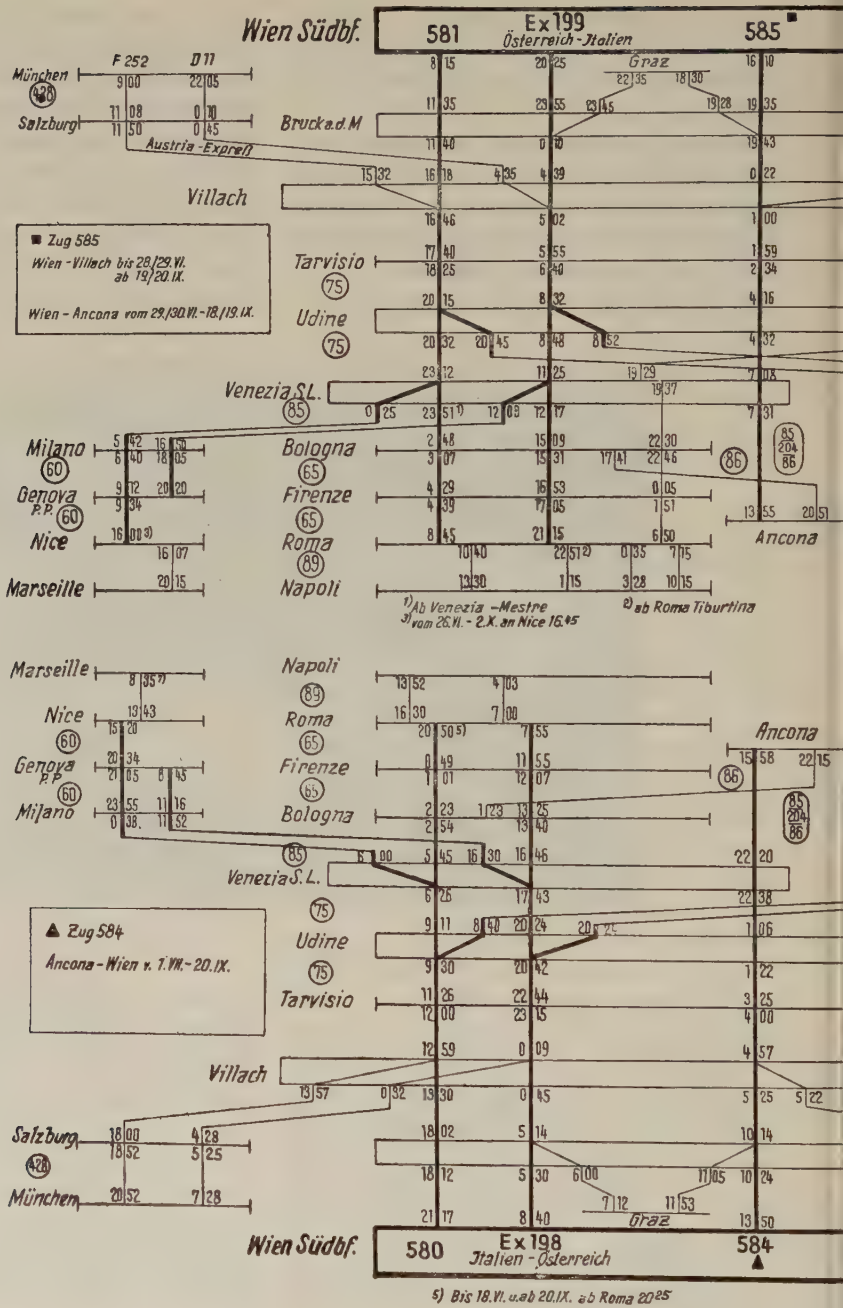
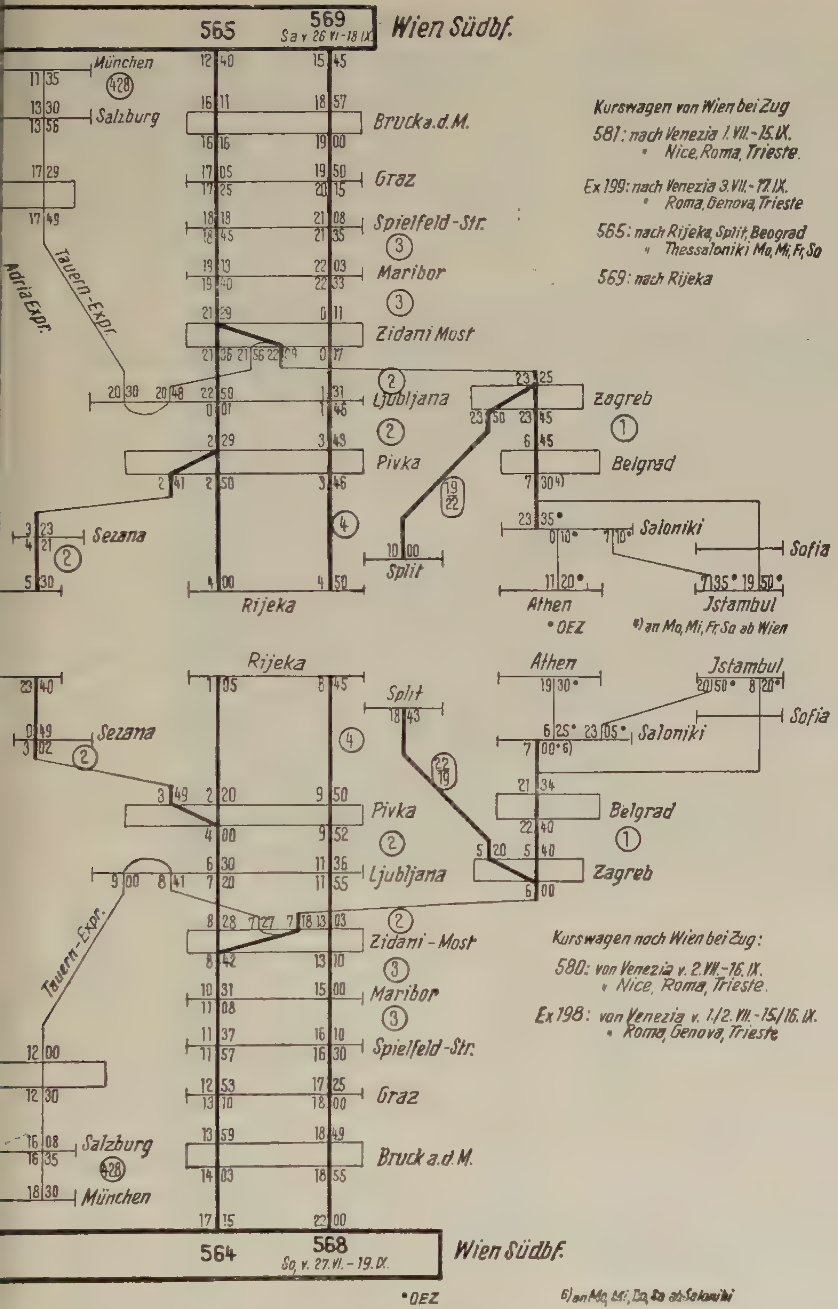


Fig. 3. — Extract fro



hrough coach services.

the table on the top left hand portion. To the right of the section there is the call disc and below it a switch which makes it possible to short-circuit the microphone which is fitted on a bracket.

In the right hand portion the official Austrian train timetables are kept in a drawer, mounted on cards. The cards are grouped according to the number of the timetable, which is indicated on the tabs of the cards. Figure 4 shows one such card.

The surface of the table is slightly inclined towards the front to give a good working angle. The drawers below it to the left and right (fig. 5) are intended to hold other cards, or to house synoptic cards stuck on cardboard.

A seven compartment pigeonhole forms the back of this working table. With the exception of the second compartment which holds the loud-speaker, these are used for foreign timetables, a list of places, rating documents, etc. In the fifth compartment above the commutators for the amplifier and a call trembler are mounted on a special rail, as well as a small control lamp which indicates that the loud-speaker telephone installation is working.

As figure 2 shows, the different desks, which are arranged side by side, are sound insulated from each other by partitions. A tubular lighting fitting on this partition throws light upon the files and on the centre portion of the work table.

The back partition of the desk, which is also insulated, can be removed. It encloses a place in which the branch line and amplifier for the loud-speaker telephone installation are housed (cf. fig. 6).

3.5 *Layout of the office.*

The Central Enquiry Office has been set up in the offices of the General Management of the Austrian Federal Railways, where the railway automatic telephone exchange (Basa) is also sited, so that the technical equipment can be maintained without additional labour costs.

The room in which the offices are situated adjoins the : Basa » so that the cables could be kept to the minimum length.

To begin with there were 9 desks, arranged in three rows of three, so that the staff could face one of the walls of the room.

On this wall are three tables giving the up-to-date information required for the work : to the left, the special trains together with their arrival and departure times; on the centre table, arranged according to the terminus stations of Vienna, delays to trains arriving; on the right, any changes in route, any special service instructions and other communications.

Above these tables is the lamp indicator with the call lamp for each line, the lamp showing when an enquiry has been held up for a long time, and the « occupied » lamp.

In addition, there is a clock, run off the central time installation, which shows the exact time.

The walls and ceiling are covered with sound insulating material. Fluorescent lights give uniform lighting throughout the room.

There is a special air conditioning plant which renews the air six times an hour.

During cold weather, the fresh air is heated according to the temperature.

3.6 *Central installation.*

The selectors and groups of relays, together with their accessories, including the recorder, are housed in standard frames (height : 2,400 m; width 600 mm). The complete installation is shown diagrammatically in figure 7, whilst figure 8 shows the equipment installed in a series of frames.

When the installation was put into service, only frames GR 3 to GR 5 were fitted and these were afterwards (at the time the photograph figure 8 was taken) completed by the frames GR 1 and GR 2, and later on by GR 6.

In GR 3 are mounted the equipment for the principal lines; in GR 5 those for the desks, whilst GR 4 contains the recorder equipment in its upper part together with the relay breakers and the control equipment; in the lower part there are the classifying selector including the spare classifying selector as well as the connecting groups of relays.

As a comparison of figures 7 and 8 clearly shows, when the photograph was taken the installation included selectors and groups of relays for 16 principal lines, 12 desks and 30 circuits, and groups of relays for four other principal lines and four desks.

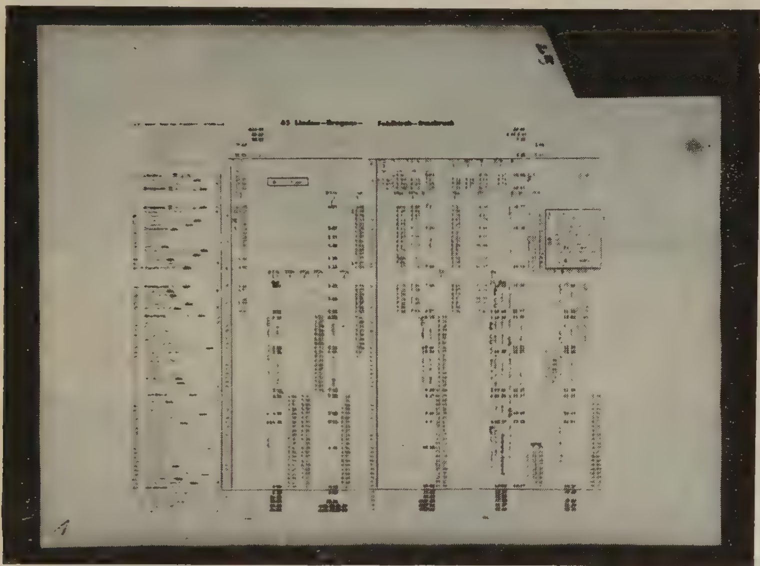


Fig. 4. — File.

Frames GR 1 and GR 2 contain the equipment for the station telephone boxes, about which we will speak later on.

The equipment of the frame is similar to that in use in telephone exchanges, especially as regards the installation of

Fig. 5. — Office where enquiries are dealt with.

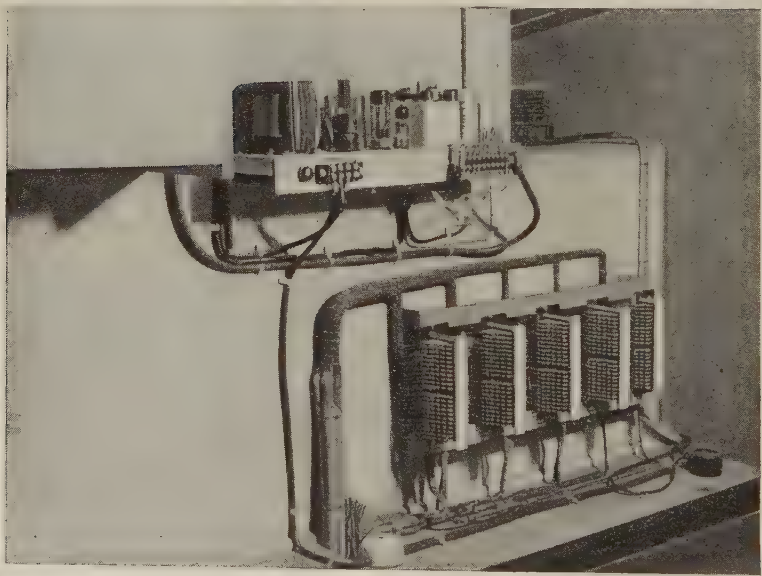


Fig. 6. — Rear view of incoming operating desks (back partition removed).

signal lamps, fuses, « occupied » lamps and tests jacks, conducting the current, shunts, etc.

The assembly of the parts which represent products of Austrian industry for low voltage was carried out, as well as the fabrication of all other parts by the railway staff, in the main telecommunications shop of the Austrian Federal Railways in Vienna. This work, together with assembly on site was carried out in the remarkably short period of three months.

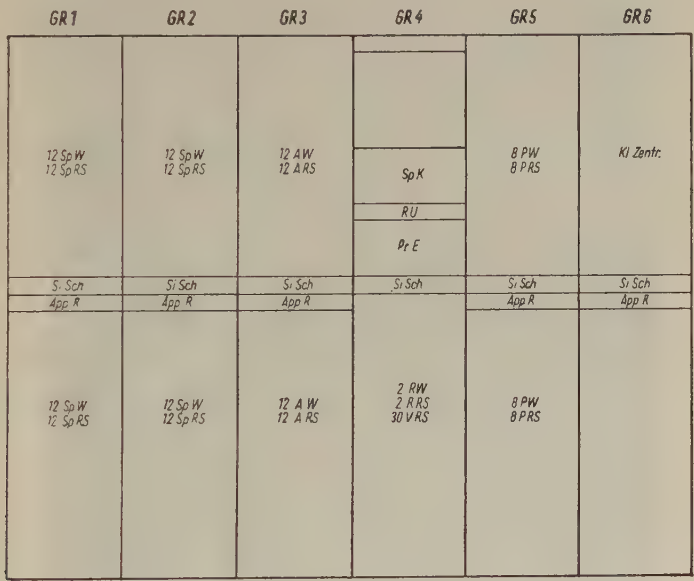


Fig. 7. — Central equipment. General arrangement (sketch).

AW = Preselector
ARS = Group of relays for principal line
PW = Selector of operating desk
PRS = Group of relays of operating desk
RW = Classifying selector
RRS = Groups of relays for classifying
SpW = Telephone box selector
SpRS = Group of relays for telephone box
SpK = Recording device
RU = Relay trembler
PrE = Control equipment
VRS = Group of relays for branch line
Si Sch = Fuse rail
AppR = Frame holding the equipment.

4. Telephone boxes.

In the spring of 1953 the first tests were carried out with a view to suppressing the giving of verbal information directly in the stations of Vienna, and progressively replacing this method by telephone boxes linked up with the Central Enquiry Office.

The first station chosen for this purpose was the Francis-Joseph Station, which is of secondary importance from the point of view of long distance traffic, but deals with a considerable amount of local traffic.

The telephone boxes on the outside are similar to the public call boxes, but as figure 9 shows, are specially marked.

The inside of the box is fitted with a loud-speaker telephone instead of an

ordinary telephone which is connected as soon as anyone enters the box. At the same time the enquiry is classified at the central enquiry office as a call from the public telephone system and treated in the same way. The client in the box like any caller on the public system gets the reply « Enquiry Office, one moment please » from the recording equipment whilst waiting for the enquiry staff to reply.

The amplifier of the loud-speaker telephone installation is fitted in an insulated part of the telephone box partition (fig. 10). The door has a circular opening, closed by a grill, behind which is the microphone. The loud-speaker is behind an opening in the sloping part above the

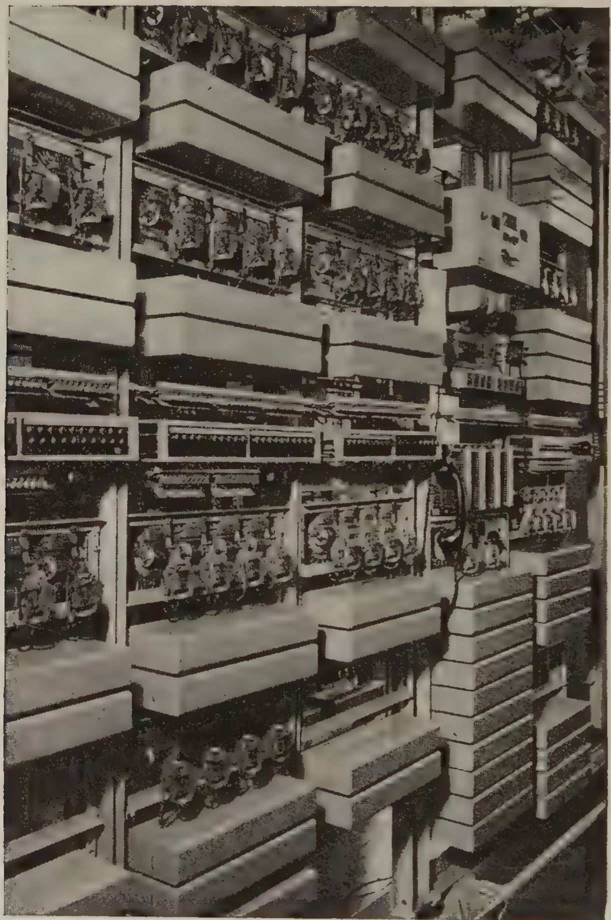


Fig. 8. — Central equipment. Part view seen from the front.

door. Underneath this there is a desk lit up by a light which goes on when anyone goes into the telephone box.

As verbal enquiries were answered free of charge in the stations, no payment is required for using these telephone boxes.

Fig. 9. — Telephone boxes.

At the central installation, the selectors of the groups of relays needed for the connections to the telephone boxes are mounted in frames GR 1 and GR 2.

As figure 8 shows, on the outside they look like the corresponding equipment for the principal lines.

5. Practical experience.

At the time when the new Enquiry Office was under consideration, there were only isolated lines for the different stations, and these were far from sufficient for requirements. Except as regards the counting of communications which was done by check counts, there were no

figures available for the amount of traffic capable of being used as a criterion for calculating the new installations. In particular, information was lacking about the time previously lost at the telephone exchanges, which would have made it possible to judge how many lines were needed. A system of 10 lines was therefore arbitrarily taken as sufficient, this hypothesis resting solely on the fact that a complete system of this size was capable of dealing with considerably more traffic than the six isolated lines and two groups of lines previously in service.

In the same way, the hypothesis that nine operating desks would be sufficient to ensure that the waiting time would not be too long was an arbitrary one, as nothing was known regarding the average length of time for the occupation of a line and conversations.

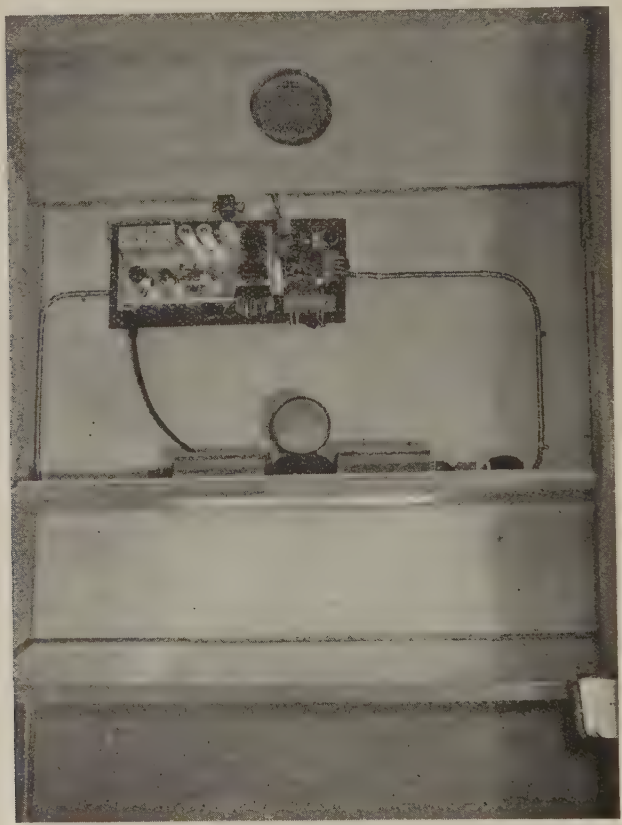


Fig. 10. — Telephone box. View showing part of the interior. Insulated partition open.

To begin with it was necessary to do

away with such unknown factors in the new installation. Reserve equipment, of which we have already spoken in the previous chapter, was installed so that if needs be the number of principal lines and desks could be increased at any time.

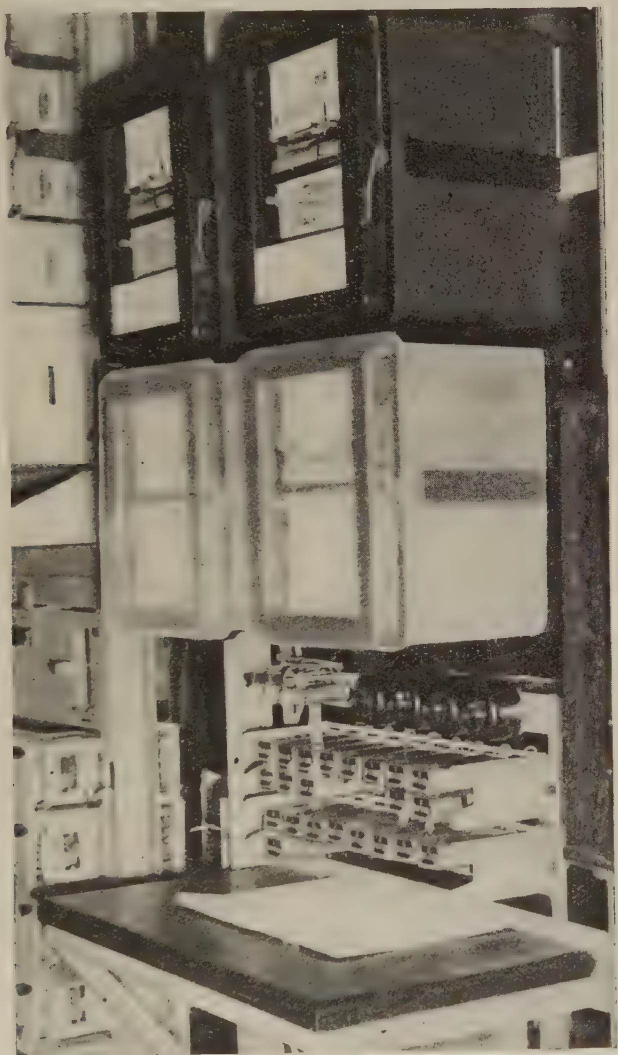


Fig. 11. — Milliamperemeter recorder and call counter.

To estimate the amount of traffic, contacts were inserted in the groups of relays for the principal lines and desks which made it possible to determine the number of times they were used by means of special counters; to determine the

units of traffic, a recording milliamperemeter was fitted for the principal lines and desks, each of these two equipments being branched on the current by ohmic resistances of high value, so that the occupation of n principal lines or n desks has a corresponding amplitude n times greater. With a uniform foreward movement of the paper, the surface between the curve inscribed and the basic position of a recorder gives the measure of the units of traffic transmitted.

Figure 11 shows a recording device in which the two recorders, we have just mentioned, can be seen, recording fluctuations in the traffic, that on the left on the principal lines, that on the right at the desks. The panel above the desk contains the apparatus counting the occupation of the principal lines and desks.

Counting the number of occupations and recording the fluctuations in traffic on the principal lines began on the 29th May 1952, and the same operations in the case of the desks on the 5th July 1952. They have been continued for two years with a few interruptions.

As figures 12, *a* to *k* show, the total occupation of the principal lines during the 24 hours varies considerably. In general, there is a weekly rhythm which always includes a maximum towards the weekend or before holidays and a minimum on Sundays and public holidays (in dark figures in figures 12, *a* to *k*), and the day after such holidays, higher values than before them. Before double public holidays : Easter, Whitsun and Christmas, the number of communications is double or more than double the normal weekend figure.

During the holiday season (July, August), there is an increase in the number of calls for a certain time before this begins. In the same way, the falling off in the desire to travel which is manifest in the second half of August has its repercussions on the number of calls.

Events which lead to a considerable falling off in the passenger traffic, such as the disastrous floods of July 1954, which for more than a week cut the western line, the most important line out of Vienna, so that traffic had to be diverted to the southern line, had an enormous effect upon the number of enquiries.

In the same way, every change in the timetables increases the work of the enquiry office. When holidays occur soon after the timetables have been altered this may lead to particularly accentuated peaks in the number of calls (for example Whitsun in May 1953).

Periods of bad weather reduce the desire to travel and lead to a falling off in the number of calls. For this reason the average number of enquiries per twenty-four hours was somewhat lower in 1954 than in 1953.

The two telephone boxes put into service on the 14th May 1953, calls from which were first recorded on the 19th May 1953 led to an increase in the number of enquiries. The corresponding figures are shown separately in the diagrams, but are included in the cumulative curve in heavy type. These figures for the number of calls undergo a smaller weekly fluctuation than that shown by the principal lines, and merely show seasonal variations.

The records show however that the

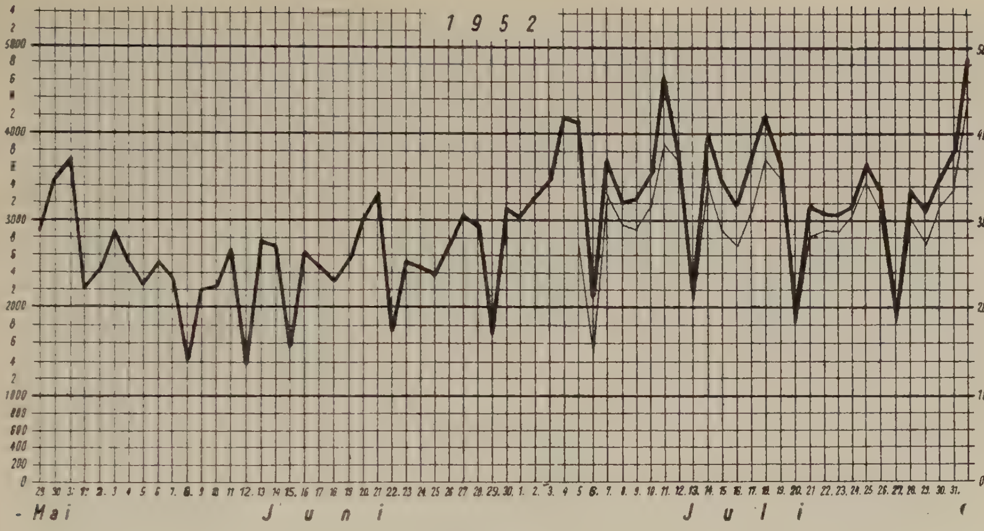


Fig. 12*a*.

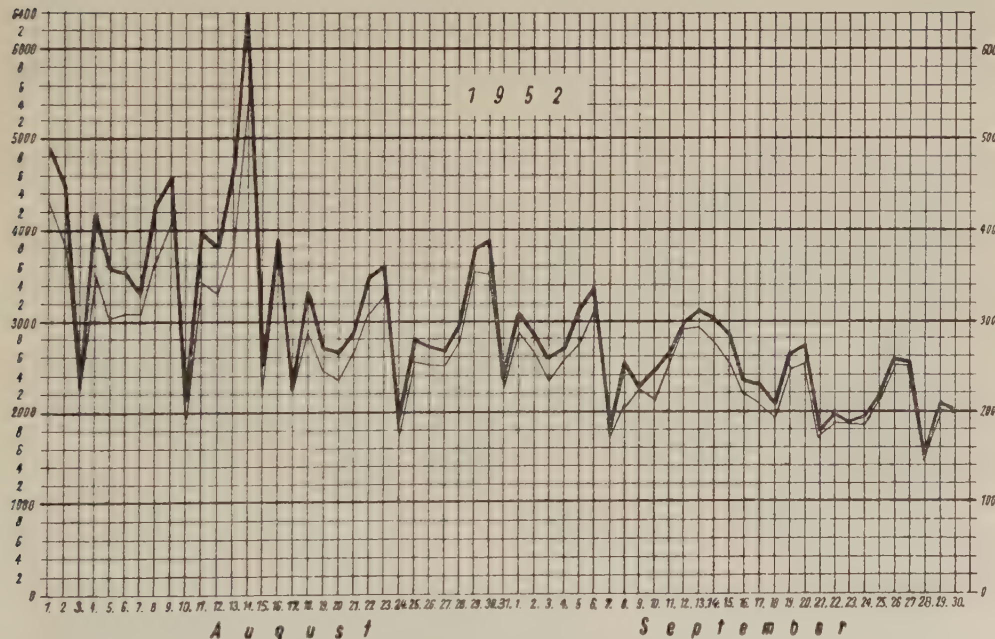


Fig. 12*b*.

Fig. 12, *a* to *k*. — Total calls for 24 hours.

Heavy type = total calls received from principal lines and telephone boxes.
Fine type = total replies.
Fine lines with figures per day = total calls from the telephone boxes.

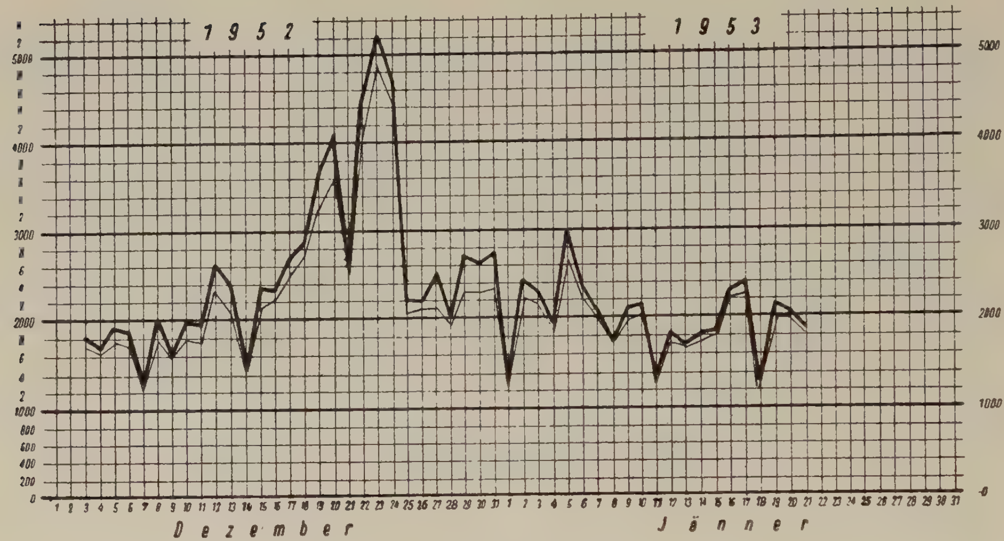


Fig. 12*c*.

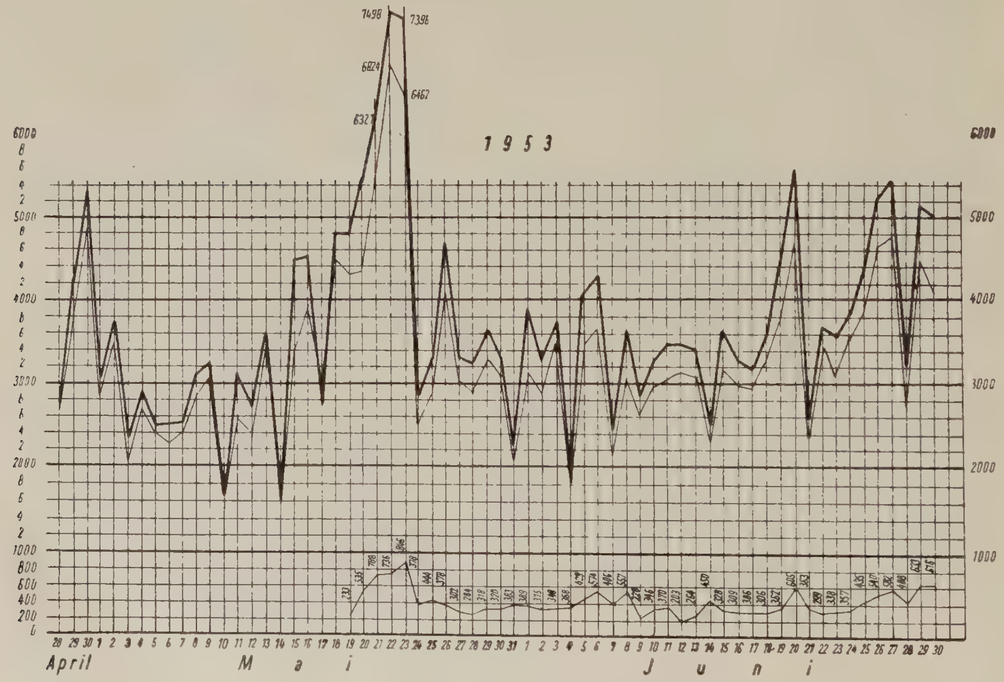


Fig. 12*d*.

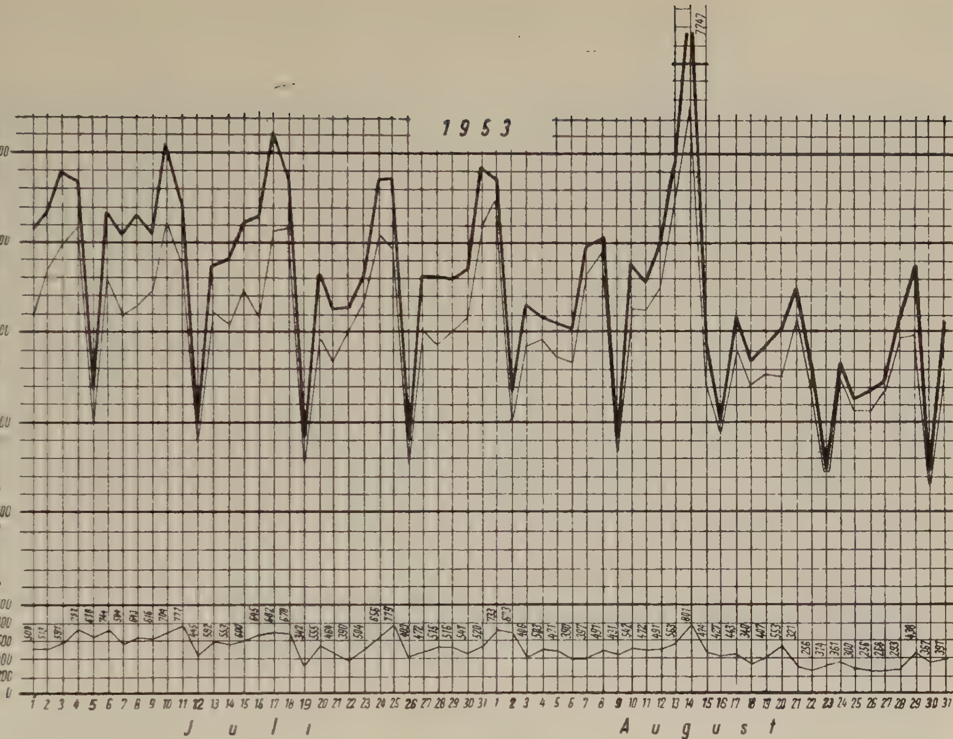


Fig. 12e.

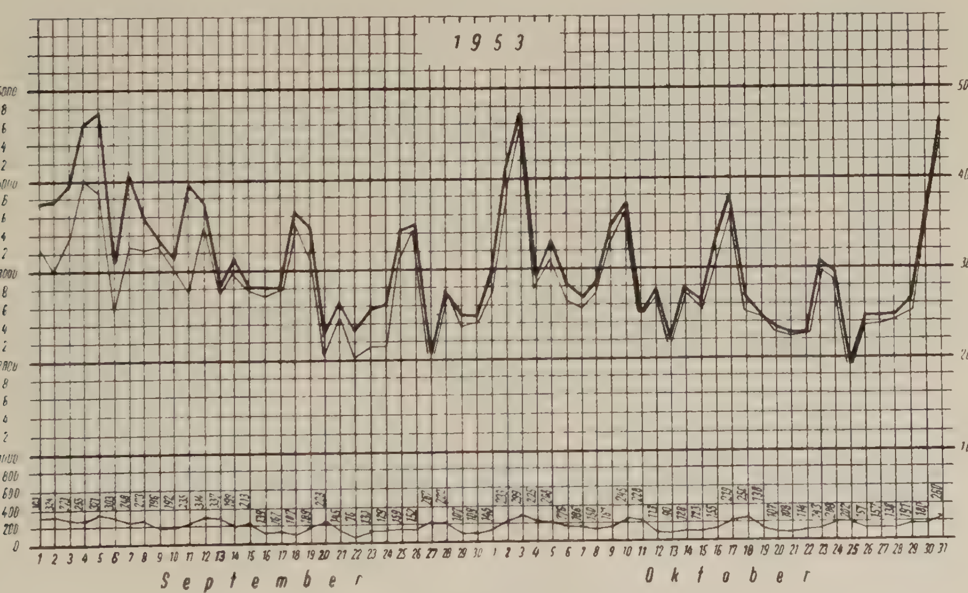


Fig. 12f.

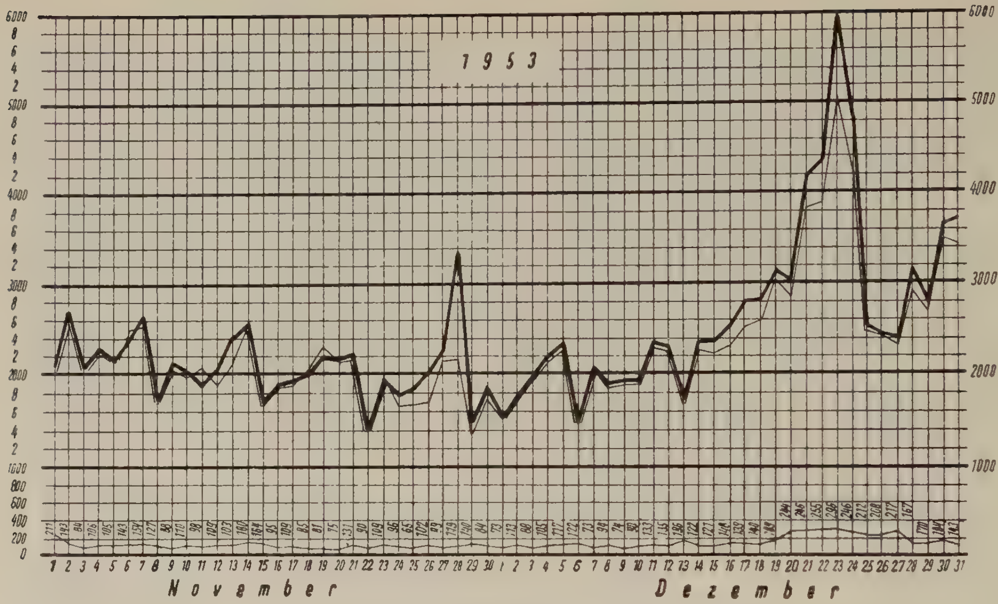


Fig. 12*g*.

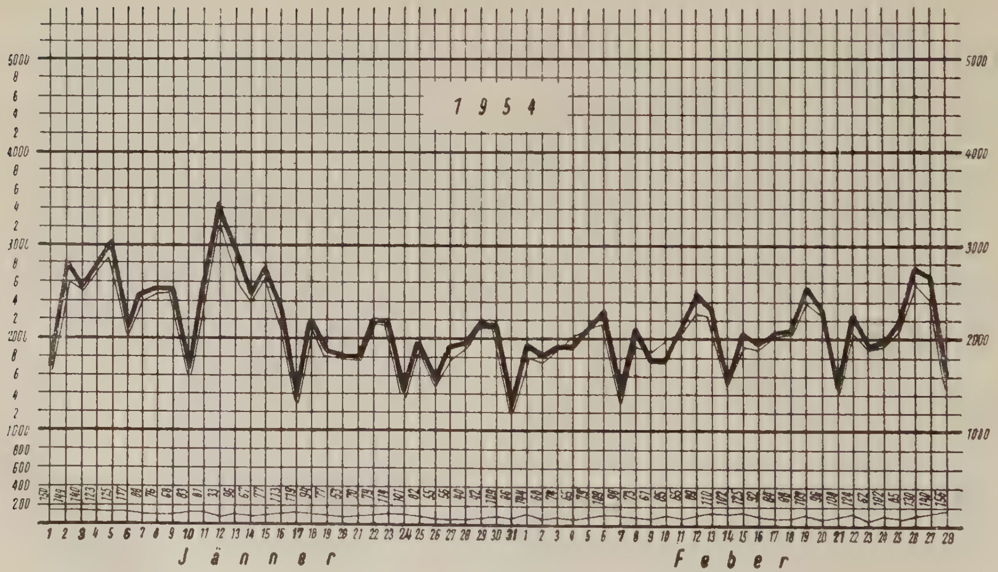


Fig. 12*h*.

installation of new telephone boxes in stations with heavy passenger traffic to replace completely the answering of enquiries verbally makes it essential to increase the number of desks at the central office unless the waiting period considerably at times of heavy traffic, although the average waiting time of 25 to 30 seconds was not exceeded on the whole, except at peak hours.

The reason why callers ring off before the enquiry office has replied must be

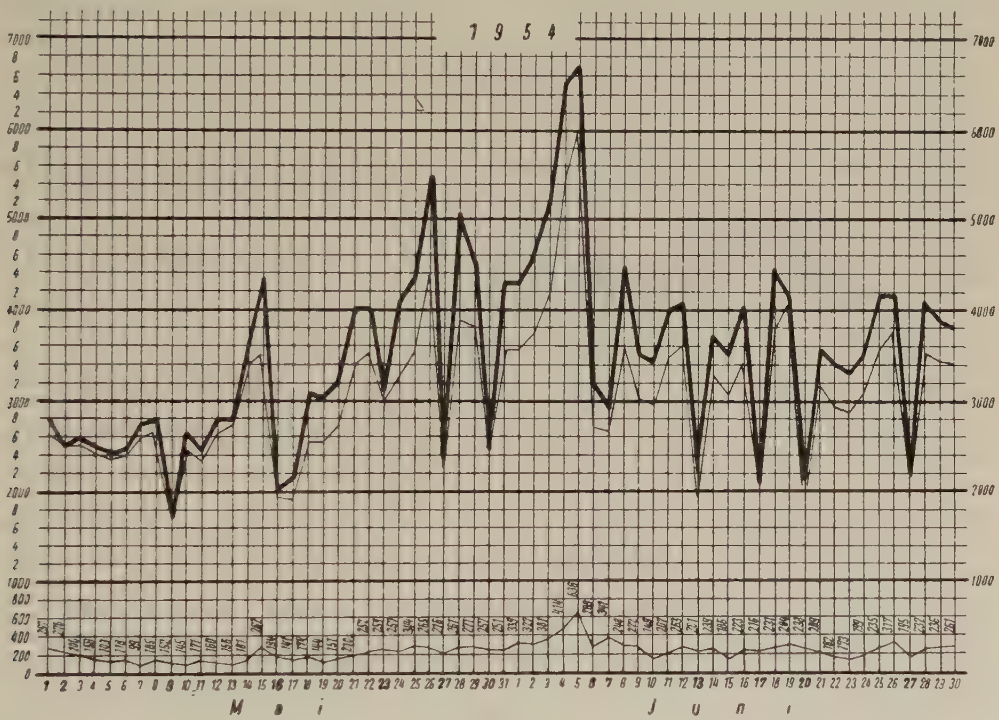


Fig. 12*i*.

in the railway telephone boxes and loss of time at the central enquiry office are to be increased. Whereas before the two boxes were put into service the difference between the number of calls and enquiries answered (shown in fine lines in fig. 12, *a* to *k*) amounted to 1.5 or 11% of the number of calls, this latter figure was due in general to an insufficient number of staffed desks, this afterwards increased

looked for on the one hand in the fact that in Vienna public calls are charged on a time basis, in other words the cost of the call depends upon the time the line is occupied. For the same reason, the time of a call from the public telephone box is limited. On the other hand, although to a lesser extent, there may be a wrong number. There may be calls from people who in spite of the notices

have mistaken the boxes for public call boxes. As the call is recorded in the central office as soon as anyone enters the box, if the caller perceives his mistake and leaves the box before the enquiry office replies, he cannot be given an answer. The fact that calls on the public telephone system are charged on a time basis may also contribute to the fact that callers stop trying to make the call if the enquiry office does not reply immediately.

Breaking down the calls shows that for the months June to September 1953 there was an increase of 36 % in enquiries compared with 1952, the increase for the lines linked up to the postal telephone system being on the average 23 %. The months of May to July 1954, compared with 1953, showed a reduction of about 4.5 % in the total number of calls, which as we have already said, must be attributed to a disinclination to travel owing to the bad weather. During the holiday season, the number of calls from the two telephone boxes amounted to about 11 % of the total enquiries.

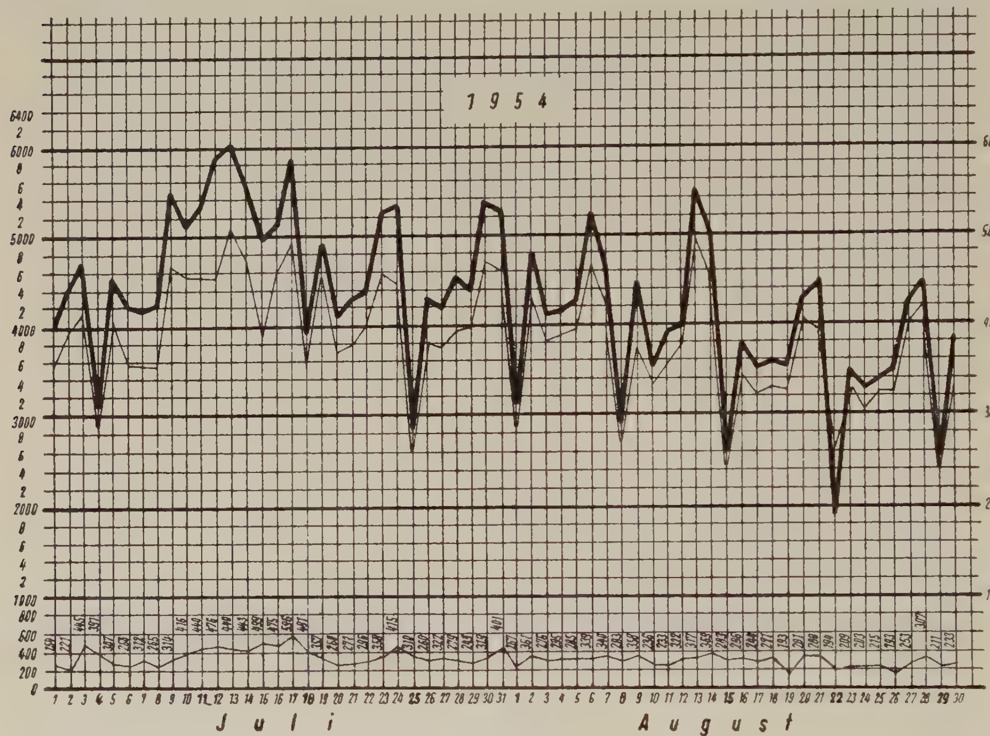


Fig. 12*k*.

The records made by the milliamperemeters have made it possible to prepare curves for the traffic values, an example for certain days being given in figure 13. These show that in general the busiest time is in the morning, between 8 and

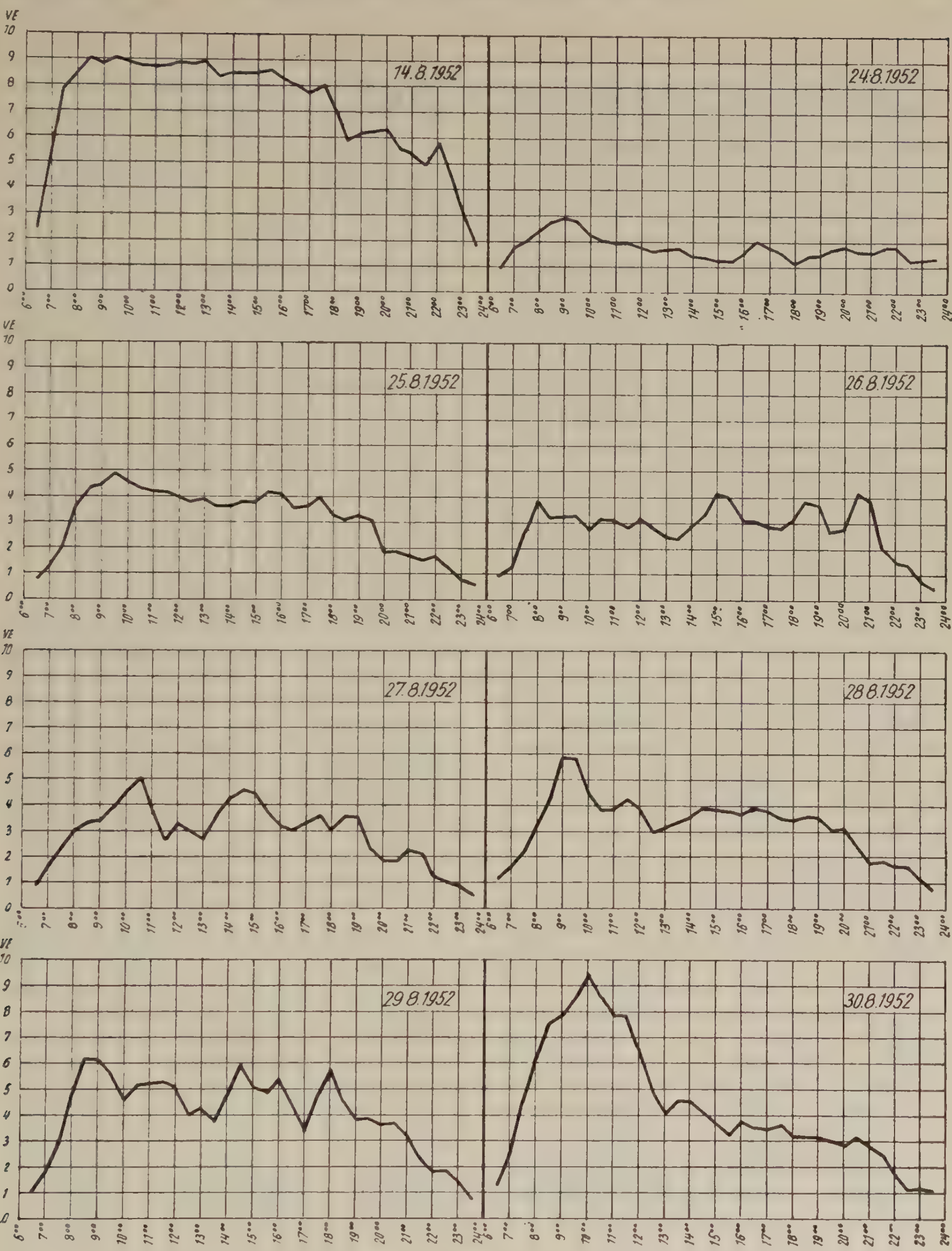


Fig. 13. — Fluctuations in traffic in units of traffic per 24 hours.

10 a.m. This is particularly noticeable on Saturdays (30 August 1952).

The average time taken for a call, taken from the traffic values and number of calls, amounts to 1.5 minutes.

The telephone traffic, which is always very fluctuating and in addition may increase suddenly in unpredictable proportions owing to various happenings, as well as the tendency to satisfy clients as far as possible on the one hand, and and on the other hand, to maintain an economic number of staff, avoiding excess labour — which is bound to lead to a reduction in output — are two conditions which have the same ratio as, for example, the traffic of a telephone exchange and the economically admissible number of connections. In the one case as in the other, callers must make certain allowances.

In the case of the Central Enquiry Office, it soon became apparent that apart from the holiday season, public holidays of more than one day (Easter, etc.) and alterations to the timetables, the service could be worked with 19 employees, so arranging the rota that it corresponded with experience gained in practice, holidays being taken mainly during periods of low trafic. When the traffic is heavy, additional staff is required.

The nine reception desks have proved sufficient to date, apart from very heavy traffic peaks. In the case of enquiries which take a certain amount of time to reply to, for example advising on routes for journeys abroad, in order to avoid the expense of long calls and to free the principal lines quickly, the following procedure has been adopted : the client, after explaining what information he requires, gives his telephone number and when the reply has been prepared by another amployee of the Central Enquiry Office, he is rung back.

The new institution has been very favourably received by the public in general, and on several occasions has spontaneous tribute in the press, as the following extracts show :

Wiener Montag, 8th December 1952 :

« What pleases us : That telephoned enquiries regarding train services to the Austrian Federal Railways are now rapidly and thoroughly answered by Vienna B 28 5 40. »

Arbeiter-Zeitung of 10th January 1953 :

« ... The new installation is already very much in demand. In June there were 72 400 calls, in July 103 000 and in August more than 125 000. »

Wiener Montag of the 27th July 1953 :

« What pleases us : That the Central Enquiry Office regarding train services always gives the information very thorougly and politely, according to international custom, even at very busy periods like the present when, if the information is not available immediately, they ask for the caller's telephone number and ring him back. »

Der Abend of the 28th August 1953 :

« ... By dialling the number B 28 5 40, there is an immediate reply from the Central Enquiry Office of the Federal Railways or else a female voice asks the caller to wait a moment.

« To say the truth, it is rare that there is a long wait. After a very short time, a man or woman voice will ask what information is needed. Details about the running of the trains, delays, or fares are given so quickly that the caller is amazed. The employees of the Enquiry Office must either be magicians or endowed with exceptionally good memories ! Otherwise how could they possibly answer any enquiry so quickly? »

[625 .216]

Buffer shock,

by Dr.-Ing. E. h. Ernst Kreissig, Krefeld-Uerdingen.

(Eisenbahn-Technische Rundschau, May 1952.)

A railway vehicle is not only subject to the accelerations and retardations imposed by the tractive and braking stresses applied in the direction of its longitudinal axis, but also to sudden variations in speeds, i.e. actual vertical, longitudinal and transverse shocks, which in the particular case of railway cars are due to the setting of the points in the track and to the action of the buffers. This depends for its absolute value on operating conditions and more particularly on the work done at the sorting points, as also on the method of applying the brakes, and these effects are actually more important than all the other shocks combined, as produced under normal working conditions. It is the cause not only of damage arising strictly speaking in the running of the behicle and to its loading, causing fracture and strain, but also to more insidious stresses resulting in unexpected fatigue of certain parts and hence to the premature need for repairs. As a matter of principle that concerns the designer, the permissible static stress should be kept below the elastic limit, and that of the dynamic stress below the limits of fatigue of the metals concerned. However, there are exceptions. Thus for example, moderate plastic deformation may be permitted in hyperstatic systems in order to ensure equilibrium of moments in the spans and at the supports, and likewise corresponding tensile stresses, provided one can be sure that the direction of the stresses in the structural parts concerned will remain unchanged. If the direction of the stresses varies, as is the case in railway work, we get in the case of repeated short periods in which the elastic limit is exceeded, a possible risk of fracture, due to the « Bausching effect ». This condition arises when a bar which has been stressed beyond its elastic limit, for example, is followed by a sharp stress in the opposite sense and shows plastic deformation, even under low stress, i.e. showing that the elastic limit and relatively therefore also the possibility of working within such limits has been considerably reduced. Apart from a certain number of these repeated stresses, there is danger of fracture of the metal by fatigue and also due to increased corrosion, on account of the formation of local galvanic couples with the metal that is not affected by the elastic deformation. In a railway vehicle subject to excessive shocks in marshalling yards or to braking actions both short and alternating, which are both axial and eccentric, a portion of the fittings becomes subject to the « Bausching effect ».

When examining the nature of the buffer shocks it should be borne in mind that in this case it is a question of a purely dynamic phenomenon which cannot be judged by static methods and cannot be influenced by them. The acceptance rules which provide for static compression measured in line with the axles, can have no other object that to secure for all the vehicles embodied in one and the same train, an equal horizontal resistance in the longitudinal direction, in order to secure, in case of violent longitudinal reactions in the train, adequate longitudinal rigidity of the whole, so as to meet the requirements of the complete train.

When one vehicle collides with another, the effect of the blow depends essentially on the strength of the buffer springs, but it also depends on the effects of elastic and non-elastic deformation of the type of waggon and of its load. These latter measurements depend largely on the nature of the load, thus the energy balance of buffer shocks in the case of two-axle box cars, showed that after the trials, when the

shock of collision still remained in the « elastic » state, and for goods loaded in bulk, such as coal, coke, etc., the work corresponding to the elastic deformation of the type of waggon, especially its springing and suspension and its frame, as also, to the internal friction of the load during its displacement, is practically equal to the loads which can be dealt with by modern buffers.

For a rigid load, the foregoing estimate will evidently be smaller and according to the type of waggon, would appear on average estimate to amount to about 25 % of the elastic strength of the buffer springs.

Moreover, there is great diversity between the possible buffer shocks, according as the gross weights of the adjacent loads are similar or differ substantially. In order to determine the necessary strength of buffer springs, it is desirable to start with the maximum permissible loads, which will definitely reduce the number of cases to be allowed for, it being understood, that such load is made up of the number of axles and the permissible load per axle. Starting with the above data we can determine the speed of the permissible shocks on a basis of the axial shock, which when impact of two waggons of similar type takes place, should be damped out solely by the elasticity of the buffer springs and of the frame of the waggon as also by the work done by friction due to the load.

If we call the energy exerted by a buffer spring A, m the mass of a loaded vehicle which collides at a speed v with an identical but stationary vehicle, the kinetic energy will be

$$E = \frac{m\ v^2}{2}$$

and the power available at the buffers 4 A. If the blow remains purely elastic up to the speed v_1, which the two vehicles reach at the same instant, we have according to the theorem of the conservation of quantities in motion (i.e. conservation of momentum) :

$$m\ (v - v_1) = m\ v_1\ ,\ \text{or}\ v_1 = \frac{v}{2}\ .$$

The kinetic energy E_1 remaining after the shocks in this case :

$$E_1 = \frac{2\ m\ v_1{}^2}{2} = \frac{m\ v^2}{4} = \frac{E}{2}$$

and the difference :

$$E - E_1 = \frac{m\ v^2}{4}$$

must be absorbed by the buffers. Assuming that in the case of goods loaded in bulk or endowed with elasticity, the overall energy absorbed by the buffers, the waggon frame and the load, comes to about double the work done by all the buffer springs taking part in the shock, and we have :

$$(1)\ E - E_1 = \frac{m\ v^2}{4} = 8\,A,\ \text{whence}\ A = \frac{m\ v^2}{32}$$

But if the load is rigid and non-elastic, the proportion of energy in the collision absorbed by the elements concerned is less and may be assessed at about 25 % of the power in the buffer springs.

Then we have :

$$E - E_1 = \frac{m\ v^2}{4} = 4\,A + 0.25 \cdot 4\,A = 5\,A,$$

and

$$(2) \qquad A = \frac{m\ v^2}{20}$$

For the goods waggon with two standard axles, with a load of 16 tons per axle, the gross weight is set at 32 000 kg. Hence, if it is a question of goods in bulk and of *volute springs*, each having a unit energy of 430 kgm, we find according to equation (1) :

$$v = \sqrt{\frac{32 \cdot 430}{3\,200}} = 2.07\ \text{m/sec},$$

$$\text{or}\ \sqrt{} = 7.45\ \text{km/h}.$$

and if it becomes a question of a rigid load, then according to equation 2 :

$$v' = \sqrt{\frac{20 \cdot 430}{3\,200}} = 1.64\ \text{m/sec},$$

$$\text{or}\ \sqrt{}' = 5.9\ \text{km/h}.$$

With *cup springs* of A = 1 250 kgm, we shall get under the same conditions :

$$v = \sqrt{\frac{32 \cdot 1\,250}{3\,200}} = 3.54 \text{ m/sec,}$$

$$\text{or } \sqrt{} = 12.7 \text{ km/h,}$$

$$\text{or} \quad v' = \sqrt{\frac{20 \cdot 1\,250}{3\,200}} = 2.8 \text{ m/sec,}$$

$$\text{or } \sqrt{}' = 10 \text{ km/h.}$$

For a maximum admissible operating speed of V = 15 km/h or v = 4.16 m/sec, the necessary power for a buffer spring in this case for a bulk load, would be :

$$A = \frac{m\ v^2}{32} = \frac{3\,200 \cdot 4.16^2}{32} = 1\,730 \text{ kgm}$$

which can be realised with cup springs.

The question of the reactions due to increase of energy in the buffer springs is indeed a problem less easy of solution by the statistical method; actually compared with the cases referred to above concerning the collision of two vehicles, both provided with volute springs or cup springs, the case occurring most frequently should be collisions between two vehicles provided with different types of buffer springs, if the numbers of buffers of the two types are the same. In such case, using volute springs and cup springs, the energy available is :

$$A = \frac{1\,250 + 430}{2} = 840 \text{ kgm}$$

$$\text{and} \quad v = \sqrt{\frac{32 \cdot 840}{3\,200}} = 2.9 \text{ m/sec}$$

$$\text{or } \sqrt{} = 10.4 \text{ km/h}$$

$$\text{and} \quad v^1 = \sqrt{\frac{20 \cdot 840}{3\,200}} = 2.3 \text{ m/sec}$$

$$\text{or } \sqrt{}^1 = 8.25 \text{ km/h}$$

values which are naturally much below the speeds which can be attained when all the buffers are provided with cup springs, but very far above the limit that can be reached if we are only dealing with volute springs. The result is that when the waggons are fitted with buffers of the two types, of different absorbing powers, the waggon provided with springs which can absorb the greater energy is less spared than if it had collided with waggons of the same type. On the other hand, in the event of collision between two vehicles of different types, the one which has the weakest buffers finds itself greatly spared, due to the greater absorbing power residing in the other, so that it is very difficult, not to say impossible to determine statistically the influence of the absorbing power of the buffers in protecting the vehicle and its load.

Necessary maintenance costs for the one and the other type of springs will form in this respect a better means of valuation, although they do not include the cost of breakage or damage to the vehicles or to the loads carried.

It is now a useful question to enquire whether in the case of 4-axle waggons, the adoption of buffer springs of greater power would be economically justified. In view of the relatively small number of these vehicles, this would seem to call for a negative reply, first because a new type of spring would be costly to introduce, both on account of the exchange and the need for carrying a stock and also because this type of waggon is less frequently shunted by gravity and requires additional care in its operation.

As regards the advantage of this or that type of buffer spring, it should be noted that the criterion of capacity adopted for buffer springs is often governed by the work of flattening out the metal. But we must repeat that it is not the load which is of importance, but the power consumption incurred; it is therefore necessary to find a buffer, which while ensuring a maximum output, provides the greatest amount of power for the smallest load incurred by the flattening out process.

A most instructive example in this connection is given by the rubber springs for buffers which have already been in use for a long time, especially with the Spencer-Moulton type, employed on overseas railways, for which figure 1 gives us the diagram.

It will be seen that this buffer has a flattening load of 59 000 kg, while its power is only about 1 000 kgm. In comparison the cup spring, according to fig. 2, gives a force of 1 250 kgm for a flattening load of only 35 000 kg. While the buffer with rubber spring exhausts its elasticity

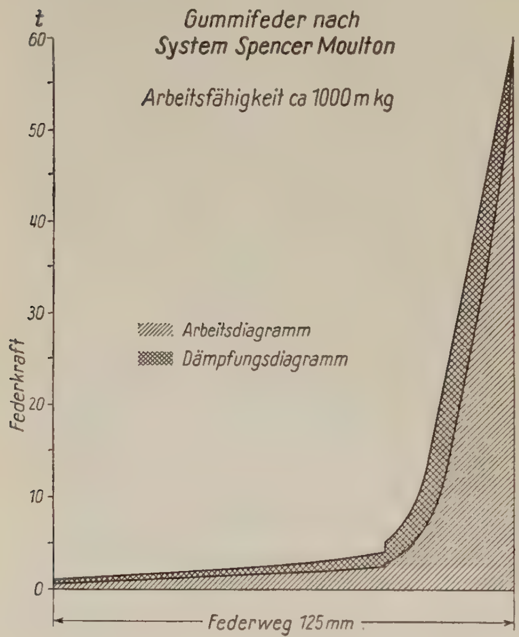


Fig. 1. — Work and damping diagram of a rubber spring Spencer Moulton system.

Gummifeder— = Rubber spring Spencer Moulton system. Capacity about 1 000 kgm. — Arbeitsdiagramm = Work diagram. — Dämpfungsdiagramm = Damping diagram. — Federweg = Travel of spring. — Federkraft = Capacity of the spring.

under a flattening load of 59 000 kg, the cup spring buffer allows a noticeable increase of that power for a shock load of only 35 000 kg, i.e. for a fatigue stress which is definitely less for the frame of the waggon. Moreover, a comparison between figures 1 & 2 shows that the buffer with cup springs deadens the shock more effectively than do the rubber springs, as will be seen by examining that part of the diagram embraced by the compression curve and by the reaction curve.

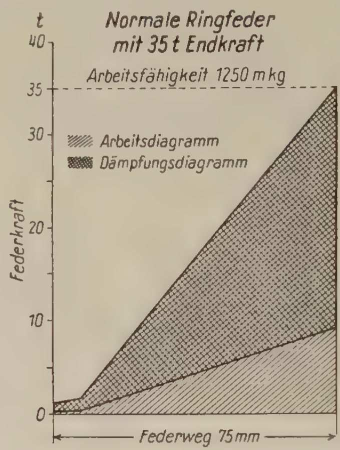


Fig. 2. — Work and damping diagram of a standard cup spring-flattening load 35 t.

Normale Ringfeder— = Standard cup spring-flattening load 35 t. Capacity 1 250 kgm.

The covering of the damping diagram, is hatched in squares (cross hatched).

Recently, plain cylindrical or nearly cylindrical rubber blocks have also been tried for damping down the shocks, but this method indicates a distinct step backward in relation to the present technique in so far as it concerns powerful shocks. To-day similar arrangements are used on the road, as traction and compression springs are inserted between the tractor and its tow; the flattening work which is attributed to these is exceptionally high, for rubber springs, but there must be a shock effect in this connection, not however due to the rubber, but to the action of the case which suffers deformation. Since as regards this effect, tests made on the materials employed might give rise to mistaken opinions, we shall go into details a little more fully. Figure 3 represents diagrammatically with figure 4 an arrangement of

this kind, i.e. a solid rubber pad in place of the spring. This shows the two separate parts. The concave curve $a\ b$ corresponds to the elasticity of the rubber and the purely linear portion $b\ c$ indicates the elasticity of the case. In this portion of the diagram, the rubber is seen to be under pressure from all sides, it can therefore only exercise a negligible effect. The deformation of the case can be measured and can likewise be calculated, by measuring the work done on deformation.

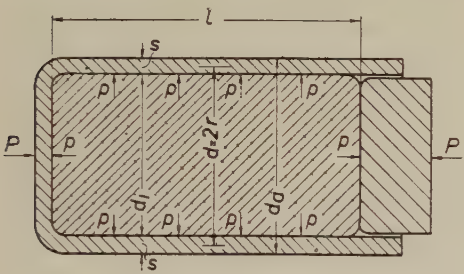


Fig. 3. — Schematic representation of a rubber block spring.

If we fill a cylinder (see fig. 3) of average diameter $d = 2\ r$ and of thickness s by means of suitable material subject from all sides

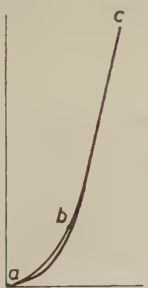


Fig. 4. — Diagram of a rubber block spring as shown in figure 3.

to a pressure p, there will be produced in the hollow cylinder a tangential tensile stress σ_z on which is superposed a slight bending stress σ_b. We should then have, sufficiently exactly for

$$r = \frac{d}{2}:$$

$$(3)\quad p = \frac{\sigma_z s}{r_i}, \quad \text{whence } \sigma_z = \frac{p\ r_i}{s} = \frac{p\ d_i}{2s}$$

and the radial extension λ_r of radius of the modulus of elasticity E, will be :

$$(4)\qquad \lambda_r = \frac{\sigma_z\, r}{\mathrm{E}} = \frac{p \cdot r \cdot r_i}{\mathrm{E}\ s}.$$

The bending stress due to curvature variation is obtained by transferring the radius of the value r to the value $r + \lambda_r$. If we bend a straight bar of rectangular section to a curve of radius r, there will be produced in this bar, for a sufficiently small modulus of elasticity, a bending stress

$$\sigma b_r = \frac{\mathrm{E}\ e}{r}$$

and for a radius of $r + \lambda_r$ under the same conditions :

$$\sigma' b_r = \frac{\mathrm{E}\ e}{r + \lambda_r}.$$

Hence if the bar of radius r is transferred to the radius $r + \lambda_r$ or inversely, it will produce a bending stress :

$$\sigma b = \sigma b - \sigma' b_r = \mathrm{E}e\left(\frac{1}{r} - \frac{1}{r + \lambda_r}\right)$$

$$= \mathrm{E}e\ \frac{\lambda_r}{r^2}$$

being in fact very small in proportion to r. If we introduce into this formula of λ_r the value obtained from equation 4, we get

$$\sigma b = \mathrm{E}e\ \frac{\sigma_z\, r}{\mathrm{E}\ r^2} = \frac{\sigma_z \cdot e}{r}$$

and since $e = \frac{s}{2}$,

$$\sigma b = \frac{\sigma_z\ s}{d}.$$

The total stress on the cylinder thus becomes :

$$(5)\quad \sigma = \sigma_z + \sigma_b = \sigma_z \left(1 + \frac{s}{d}\right) = \sigma_z \frac{d + s}{d}$$

$$= \sigma_z \frac{d_a}{d}.$$

The cylinder of radius r being stressed over the whole of its periphery, the calculation must be based on the theory of the arched girder, but in practice the value of the difference is so small that it does not justify the work of calculation. Besides the importance of this infinitesimal magnitude is still much smaller in the final result so long as the ratio $\frac{s}{d}$ remains small as is customary with the casings of buffers.

In a traction mechanism applied to road traffic shocks, in which $d = 10$ cm and $s = 0.5$ cm, we have an internal diameter $d_i = 9.5$ cm. If the elastic limit of the metal forming the case is $\sigma_s = 2\,400$ kg/cm², the casing may be stressed up to this value, but it holds in a few cases extreme only, so that we can put $\sigma = \sigma_s$.

From the formulae 3 to 5 we get :

$$p = \frac{4\,P}{\pi\, d_i^2},$$

$$\sigma_z = \frac{\sigma d}{d + s} = \frac{2\,400 \cdot 10}{10.5} = 2\,286 \text{ kg/cm}^2$$

and

$$\sigma_z = \frac{p\, d_i}{2\, s} = \frac{4\,P\, d_i}{2\, s\, \pi\, d_i^2} = \frac{2\,P}{\pi\, d_i\, s}$$

whence :

$$P = \sigma_z \frac{\pi\, d_i\, s}{2} = \frac{2\,286 \cdot \pi \cdot 9.5}{4} = 16\,985 \text{ kg}.$$

The elastic displacement f in the direction of the axis due to the elongation of the case (boitier) is then :

$$\lambda = \sigma_z \frac{r}{E} = \frac{2\,286 \cdot 5}{2\,100\,000} = 0.00544 \text{ cm}$$

For $l = 12$ cm the elastic forces of the case will be :

$$A_g = \frac{V\, \sigma_z^2}{2\,E} = \frac{\pi\,(d_a^2 - d_i^2)\, l\, \sigma_z^2}{8\,E}$$

$$A_g = \frac{\pi\,(10.5^2 - 9.5^2)\; 12 \cdot 2286^2}{8 \cdot 2\,100\,000}$$

$$= 234 \text{ kgcm}.$$

Since :

$$A_g = \frac{P\,f}{2},$$

we get : $f = \frac{2\,A}{P} = \frac{468}{16\,986} = 0.0276$ cm.

To the elastic force A_g has still to be added a small amount of work in deforming the rubber, which is subjected to the surrounding compression. If due to the shock action σ_z and consequently also P, become greater, the case becomes plastically deformed in the tangential direction and if the shock energy suffices it will be destroyed.

For a standard railway buffer, in which :

$d = 18.2$ cm, $d_i = 17$ cm, $s = 1.2$ cm,

$$\sigma_s = \sigma = 2\,400 \text{ kg/cm}^2,$$

we shall have :

$$\sigma = \sigma_z = \frac{d}{d + s} = \frac{p\, d_i\, d}{2\, s\,(d+s)}$$

$$= \frac{4\,P\, d_i\, d}{\pi\, d_i^2 \cdot 2\, s\,(d+s)} = \frac{2\,P\,d}{\pi\, d_i^2 \cdot s\,(d + s)}$$

$$P = \frac{\sigma\,(d + s)\,\pi\, d_i\, s}{2\,d}$$

$$= \frac{2\,400 \cdot 19.4 \cdot 17.3 \cdot 3.14 \cdot 12}{2 \cdot 18.2} = 81\,935 \text{ kg}.$$

But this stress could not possibly arise unless the whole of the force of the shock could be damped out by the work of deformation of the rubber and of the buffer

casing (boisseau de tampon), which could not happen on account of the limited power range of the two components. Consequently, the plunger will strike the buffer plate sharply and the surplus energy of the shock will cause the buffer casing to operate by axial compression, both statically and plastically, rather than in the tangential direction. But due to the transverse elongation, directed tangentially, the stress exceeds the elastic limit in this direction, i.e. the piston of the buffer applied with great force will lend itself simultaneously to a plastic deformation, both tangentially, radially and axially.

However, there would be little advantage in increasing the thickness of the wall of the plunger, as one would thereby obtain only a linear increase in the power of the piston, which is weak in itself. This strength could only be increased appreciably by raising its elastic limit, e.g. by heat treatment of the piston made of quenched spring steel. But this suggestion is equally impracticable, due to the increase of force F which would take place. Actually we should get $\sigma_s = 10\,000$ kg/cm^2 :

$$P = \frac{\sigma_s \, d_a \cdot d_i \cdot \pi \, s}{2\,d} \simeq \frac{\sigma_s \cdot d \, \pi \cdot s}{2}$$

$$= 10\,000 \times 9.1 \times \pi \times 12 = 342\,500 \text{ kg.}$$

Thus beyond the region of elastic work, the resistance capacity of the chassis which is of 250 tons would be greatly exceeded.

Such a proposal to overcome the difficulty would moreover be illogical, seeing that the rubber pad and also the plunger would be doomed to rapid destruction, the rubber block by friction, the plunger by the vigorous and repeated blows against the buffer plate. In addition, the damping effect is relatively poor, and it introduces a serious disability in the braking and handling of the train.

Another defect arises from the diminution in the elastic properties of the rubber at low temperatures, such as occur at times in these latitudes.

These considerations apply especially to the shocks due to eccentric buffing action, which will be discussed separately in the following article.

[**625** .216]

The eccentric thrust of the buffer,

by Dr.-Ing. E. h. Ernst KREISSIG, Krefeld-Uerdingen.

(Eisenbahn-Technische Rundschau, November 1952).

The impact of an eccentrically directed collision is of special importance in the case of 2 and 3 axle trucks, owing to the fact that it subjects frames which are diagonally rigid in plan to very severe stresses which may even result in plastic deformation. Under these conditions, the axles can no longer maintain their relative positions at right angles to the longitudinal axis of the vehicle. They are thus apt to attack one of the rails at a certain angle, resulting not only in the expenditure of a considerable amount of frictional energy, but also in increased wear on the rails and axles.

According to the plan in figure 1, the frames for 2 axle wagons are made up of two side sills *a*, two end sills *b* intermediate cross bars *c*, main frames or stiffeners *d* and diagonal struts *e*.

One side sill and one stringer, together with two diagonal struts *e* and the corresponding intermediate cross bars, form a carrier system; two of these systems, shown hatched, indicate the frame. When unilateral collision takes place, the two systems slide over one another in the longitudinal direction, in spite of the resistance to bending due to the forward and intermediate cross bars which connect them together, and

subject these in the same way as in the diagonal struts, to non-elastic deformation. Far from being exceptional, these occurrences follow a general rule, unless it is considered correct practice to observe a certain difference between the dimensions of the diagonals. This may at first seem suprising, but in the absence of this tolerance the arrange-

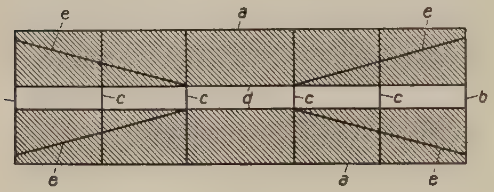


Fig. 1.

ment will not work satisfactorily with the existing gear, since we may repeat that the unilateral impulse is not an exception, but is in fact the rule.

In order to avoid the undesirable effect of an eccentric unilateral blow, it is necessary to make the chassis, particularly those intended for carrying marketable goods, diagonally elastic, i.e. to arrange that they should operate in plan in some way like springs.

The cause of the eccentric shocks originates in the lengths of the buffers which as supplied are apt to vary by $\pm$ 3 mm but which under working conditions may vary in the negative sense owing to compression of the plungers and to slight deformation of the cross bars.

A second reason for this variation, is due to obliquity of the wagon in respect to the track, which results in play between the wheel flange and the head of the rail. In the case of the wheel flanges being worn, the horizontal play between rail and wheel may reach 20 mm and even more, so that for a wheelbase of 5.4 m and spacing between buffers of 1.75 m when two wheels are in real contact and diagonally opposed, the additional play between buffers $\pm v$, given by the relation

$$\pm v = \frac{20 \cdot 1{,}75 \cdot 2}{5{,}4} = \pm 13 \text{ mm.}$$

Allowance being made for a possible tolerance of $2 \times 3 = 6$ mm in the lengths of the buffers in contact, the amount of play to be allowed for is thus $13 + 6 = \pm 19$ mm.

If however in a group formed by an elastic chassis and a very rigid frame (tank wagon) such an amount of play might well appear in each of the pairs of buffers that are in contact, i.e. negative on the one hand and positive on the other, here it would be necessary on account of the pair of short buffers to make up for an amount of negative play of $2 \times 19 = 38$ mm, due to elastic deformation of the chassis. This play may moreover be increased by the plastic deformations referred to above of the pistons and of the end sills, but it would not do to depend on an accumulation of all the unfavourable factors, an event most unlikely to occur.

In order to give us an idea of the behaviour of the elastic chassis according to its diagonals, we must elastically support a unilateral deformation of at least 20 mm due to the effect of a buffer shock from only one side, of 40 000 kg acting in the direction of the axis of the buffers. Amongst the numerous results, possible with a chassis of this nature, let us take the simplest (fig. 2) in which the side sills *a* of the chassis are

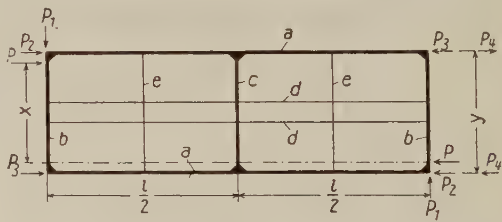


Fig. 2.

subject to a horizontal moment of inertia J_e the end sills *b* a horizontal moment of inertia J_k and the intermediate central cross bar *c* is subject to a horizontal moment of inertia J_c. By hypothesis, the intermediate cross bars *e* and the stiffeners *d*, only slightly rigid, possess only very feeble horizontal moments of inertia which do not noticeably modify the function of the combination $2a + 2b + c$.

In order to ensure the effect of maximum elasticity, as has already been pointed out, it is essential to arrange the chassis to act as a spring, in such a way that it will resist any deformation in plan, in other words that all bars shall as far as possible be stressed up to the permissible limit. However, in view of the very short duration of the non-elastic shock, during operations, it is not possible to prepare a suitable diagram for showing the stresses in the different beams, since the effects of the shocks, set free mass reactions which are highly confusing. But if we start with consideration of the static load corresponding to the regulations for acceptance of the parts under inspection, we can form a fairly good idea of their deformability or in other words of the elastic strength of the chassis.

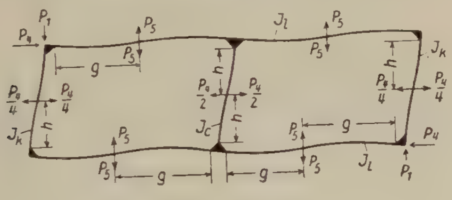


Fig. 3.

Under a diagonal load P, due to the buffer stresses (fig. 2 and 3), the chassis is subjected to a couple $P \cdot x$ which may be replaced by the couple $P_4 \cdot y$ since

$$P \cdot x = P_4 \cdot y, \text{ whence } P_4 = \frac{P \cdot x}{y}.$$

We get the same result by breaking up the force P into its components P_2 and P_3 :

$$P \frac{y - x}{2} = P_3 \cdot y ;$$

$$P_3 = \frac{y - x}{2y} P ; \quad P_2 = P - P_3 ,$$

$$P_4 = P_2 - P_3 ; \; P_4 = P - 2 P_3 = \frac{P \cdot x}{y}.$$

The forces couple $P.x$ will cause the chassis to pivot about its vertical axies, unless an equal and opposite moment equal to $P_1 \; l$ fails to oppose it. This moment is produced at the time when tests by the special machine are being carried out by the forces of inertia at the rail flanges or by friction. So that when tests are proceeding :

$$P_1 \cdot l = P \cdot x \text{ whence } P_1 = \frac{P \cdot x}{l}.$$

The stress P_1 produces in the side sills shearing stresses $P_5 = \frac{P \cdot x}{2\,l}$ provided that the intermediate cross bars are such that they resist all the same maximal stresses. But in that connection if the moment of inertia of the side sill is uniform, the intermediate cross bars ans end sills of the same width and placed symmetrically with respect to the axis of flexure, it will be necessary for the intermediate side sill to be able to support a shearing stress double that of the end sill. Thus we get in each cross bar a shear stress $\frac{P_4}{4}$ and in the intermediate cross bar a shear stress of $\frac{P_4}{2}$. Hence according to figure 3 we get :

$$\frac{P_4}{4} \cdot \frac{y}{2} = \frac{P_5 \cdot l}{4},$$

from which :

$$P_5 = P_4 \frac{y}{2\,l} = \frac{P \cdot x}{y} \cdot \frac{y}{2\,l} = \frac{P \cdot x}{2 \cdot l}$$

as has already been shown above.

For $P = 40\,000$ kg, $y = 198$ cm, $x = 175$ cm and $l = 800$ cm, we get :

$$P_4 = \frac{P \cdot x}{y} = \frac{40\,000 \cdot 175}{198} = 35\,360 \text{ kg},$$

and

$$P_5 = \frac{P \cdot x}{2\,l} = \frac{40\,000 \cdot 175}{1\,600} = 4\,375 \text{ kg}.$$

For a stress limit of $\sigma = 3\,000$ kg/cm², we get :

$$W_l = \frac{P_5 \cdot g}{\sigma} = \frac{4\,375 \cdot 180}{3\,000} = 263 \text{ cm}^3$$

$$W_k = \frac{P_4 \cdot h}{4\,\sigma} = \frac{35\,360 \cdot 80}{4 \cdot 3\,000} = 238 \text{ cm}^3$$

$$W_c = \frac{P_4 \cdot h}{2\sigma} = \frac{35\,360 \cdot 80}{2 \cdot 3\,000} = 476 \text{ cm}^3$$

W_l, W_k and W_c being respectively the coefficients of inertia of the side sills, the intermediate cross bars and the extreme end cross bars.

Since it is here a question of a purely dynamic phenomenon, we must allow the maximum elastic power to benefit the working beams. As to the side sills one can manage these with a minimum of weight by making them in the form of box girders which moreover will enable them to damp down effectively the shocks by means of oscillating counterweights, etc., and thus prevent the destruction of the side walls and particularly the vertical stanchions. Again the box girder or hollow beam considered exclusively from the point of view of spring design, is highly efficient as regards bending in all directions in the space available. The elastic strength A of the beam, of section F cm², of volume V cm³, of moment of inertia J cm⁴ and of a distance between fibres subject to the highest stresses and the neutral axis, *e* cm is for a uniform bending stress

$$A = \frac{V\,\sigma^2{}_b}{E} \cdot c\,,$$

V being the volume, σ_b the bending stress in kg/cm², E the elastic modulus in kg/cm² and *c* a factor with a value of :

$$c = \frac{J}{2 \cdot F\, e^2}\,.$$

So that, for example, the section of the side sill figure 4 has a moment of inertia in respect to the axis *zz* :

$$J_1 = \frac{24 \cdot 16{,}5^3 - 22{,}8 \cdot 15{,}3^3}{12} = 2\,174 \text{ cm}^4,$$

a moment of resistance :

$$W_1 = \frac{2\,174}{8{,}25} = 263 \text{ cm}^3,$$

a surface of section $F_1 = 24 \cdot 16{,}5 - 22{,}8 \cdot 15{,}3 = 47$ cm² and :

$$c_1 = \frac{2\,174}{2 \cdot 47 \cdot 8{,}25^2} = \frac{1}{2{,}94}\,,$$

$e = 8.25$ being the distance from the neutral axis of the fibres exposed to the highest stresses. But as in all parts concerned with the side sills, the stress rises from zero to a maximum σ_b, the elastic force A_1 of the side sill is :

$$A_1 = \frac{V\,\sigma^2{}_b}{E} \cdot \frac{c}{3} = \frac{V\,\sigma^2{}_b}{E}\,,\ \frac{1}{8{,}82}$$

If the stressed length of the two side sills is $8\,g = 8 \cdot 180 = 1\,440$ cm, $\sigma_b = 3\,000$ kg/cm² and the coefficient of elasticity $E = 2\,100\,000$ kg/cm², then we get :

$$A_1 = \frac{1\,440 \cdot 47 \cdot 3\,000^2}{8{,}82 \cdot 2\,100\,000}$$

$$= 32\,900 \text{ kgcm} = 329 \text{ kgm}.$$

We can fix the extreme cross bars and the side sills in the shape of hollow beams or of beams of U section. For the present calculation, we shall assume that it is a question of hollow beams. The section of the extreme cross bar in figure 5 shows

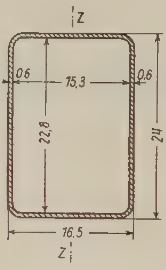


Fig. 4.

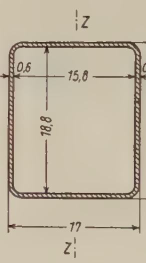


Fig. 5.

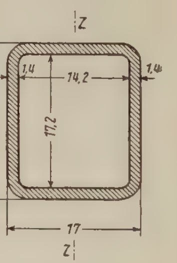


Fig. 6.

a moment of inertia in proportion to the axis *zz* :

$$J_k = \frac{20 \cdot 17^3 - 18{,}8 \cdot 15{,}8^3}{12} = 2\,022 \text{ cm}^4,$$

and a moment of resistance :

$$W_k = \frac{2\,022}{8{,}5} = 238 \text{ cm}^3\,,$$

$$F_k = 20 \cdot 17 - 18{,}8 \cdot 15{,}8 = 43 \text{ cm}^2,$$

$$c_k = \frac{2\,022}{2 \cdot 43 \cdot 8{,}5^2} = \frac{1}{3{,}07}; \ \frac{c_k}{3} = \frac{1}{9{,}21}.$$

The elastic force A_2 for the operative length of the two extreme cross bars, 4 h = 4 · 80 = 320 cm, is equal to

$$A_2 = \frac{320 \cdot 43 \cdot 3\,000^2}{9{,}21 \cdot 2\,100\,000}$$
$$= 6\,380 \text{ kgcm} = 63{,}8 \text{ kgm}.$$

For the central intermediate cross bar according to figure 6 we get in relation to the axis *zz :*

$$J_c = \frac{20 \cdot 17^3 - 17{,}2 \cdot 14{,}2^3}{12}$$
$$= 4\,014 \text{ cm}^4;$$

$$W_c = \frac{4\,014}{8{,}5} = 472 \text{ cm}^3$$

$$F_c = 20 \cdot 17 - 17{,}2 \cdot 14{,}2 = 96 \text{ cm}^2,$$

and

$$c_c = \frac{4\,014}{2 \cdot 96 \cdot 8{,}5^2} = \frac{1}{3{,}45}; \ \frac{c_c}{3} = \frac{1}{10{,}35}$$

The elastic force A_3 for the operative length of the intermediate cross bar which comes to 2 h = 2 .8 0 = 160 cm is equal to :

$$A_3 = \frac{160 \cdot 96 \cdot 3\,000^2}{10{,}35 \cdot 2\,100\,000}$$
$$= 6\,340 \text{ kgcm} = 63{,}4 \text{ kgm}.$$

The elastic force A_4 is therefore equal to : $A_4 - A_1 + A_2 + A_3 = 32\,900 + 6\,380 + 6\,340 = 45\,620$ kg/cm = 456.2 kgm.

The force P applied produces an elastic displacement f and consequently an elastic stress $A_f = \frac{Pf}{2}$;

since A_f must equal A_4, we get :

$$f = \frac{2\ A_f}{P} = \frac{2 \cdot 45\,620}{40\,000} = 2{,}28 \text{ cm}.$$

But the limit accepted, i.e. 6 = 3 000 kg/cm² can be taken up to the elastic limit, which with St52 steel reaches 3 300 kg/cm². Since the elastic force on the frame increases with the square of the stress, the elastic bending of the chassis increases likewise under the influence of unilateral buffer action. Thus there will here arise an elastic displacement f_1 given by the relation :

$$f_1 = f\ \left(\frac{3\,300}{3\,000}\right)^2 = 1{,}21\,f = 2{,}76 \text{ cm}.$$

But these figures only apply to the case of loads according to the regulations for acceptance, i.e. to an unloaded vehicle, in which the stresses due to the vertical load only play a secondary role. Now, in a loaded truck very high stresses arise, as a result of vertical stresses which can be considered as approximately equal to half the elastic limit. Since the stresses in both directions add up in the most highly stressed fibres, one would only allow in the present case for horizontal stresses up to half the elastic limit, and consequently for an elastic displacement :

$$f_2 = f\ \left(\frac{1}{2}\right)^2 = \frac{2{,}76}{4} = 0{,}7 \text{ cm} = 7 \text{ mm},$$

the deformation being assumed to be entirely static. But in reality this deformation endures for a very short time, so that we know, one would only have to allow for the elastic limit which is much greater than the static value, and even in the case of a loaded truck, the diagonal method would suffice.

When a truck having a tare of 9 000 kg collides at the maximum permissible shunting speed of v = 4,17 m/sec; v = 15 km/h with an identical truck, the energy of collision is :

$$A_p = \frac{m \cdot v^2}{2} = \frac{9\,000 \cdot 4{,}17^2}{2 \cdot 9{,}81} = 7\,980 \text{ kgm}.$$

Let us suppose that each buffer spring has a power of 450 kgm (with a volute spring) for a flattening load of 12 000 kg

and linear flexure of 75 mm. If one of the buffers is 20 mm shorter than the other, the course of one of the pairs of buffers, up to the start of the inelastic contact between the two vehicles, is 75 mm and that of the other is 55 mm; the elastic force of the 4 buffers is then :

$$A' = 2\left[450 + 450\left(\frac{55}{75}\right)^2\right] = 1\,384 \text{ kgm.}$$

At this instant the colliding wagon is moving at v_1 and the other wagon that was struck is given a speed of v_2, the balance of energy remaining is then :

$$A_p - 2\,A' = \frac{m}{2}\,(v_1^2 + v_2^2)\,,$$

since, by hypothesis, the value A' is doubled by intervention of the structure of the chassis.

On the other hand, by the theorem of quantities in motion we get :

$$m\,(v - v_1) = m \cdot v_2\,.$$

It follows that :

$$v_1 = \frac{v}{2} \pm \sqrt{\frac{A_p - 2\,A'}{m} - \frac{v^2}{4}}$$

$$= 2{,}085 \pm \sqrt{1{,}34}\,;$$

$$v_1 = 3{,}245 \text{ m/sec; } v_2 = 0{,}925 \text{ m/sec.}$$

On the hypothesis of a uniformly accelerated or retarded movement, we get, by approximation for this period of shock : mean speed of the colliding vehicle :

$$v_m = (\text{about})\ \frac{v + v_1}{2}$$

$$= \frac{4{,}17 + 3{,}25}{2} = 3{,}71 \text{ m/sec;}$$

average speed of the truck receiving the blow from the colliding vehicle :

$$v'_m = (\text{about})\ \frac{v_2}{2} = \frac{0{,}925}{2} = 0{,}462 \text{ m/sec.}$$

So, that for the approaching relative speed v_r of the two vehicles in relation to each other, we get :

$$v_r = v_m - v'_m = 3{,}71 - 0{,}462 = 3{,}248,$$

or approximately 3.25 m/sec, and for the duration of this period of shock :

$$t_1 = (\text{about})\ \frac{0{,}15}{3{,}25} \sim 0{,}046 \text{ sec.}$$

During this period there will be a moment of rotation :

$$M_1 = \left(12\,000 - \frac{75 - 20}{75} \cdot 12\,000\right) 0{,}875$$

$$= 2\,800 \text{ kgm}$$

acting of the two trucks about their vertical axes of rotation and tending to cause them to rotate inversely to one another at an angular velocity ω_1. We then get :

$$M_1 \geq J'\omega_1\,, \text{ or } \omega_1 \leq \frac{M_1\,t_1}{J'}\,,$$

J' being the mass moment of inertia of a vehicle that is light in respect to its vertical axis. We then have for J = 5 500 kgm sec²

$$\omega_1 \leq \frac{2\,800 \cdot 0{,}046}{5\,500} = 0{,}0234\,\frac{1}{\text{sec.}}\,,$$

which gives a displacement s_1 in the direction of the axis of the buffer, i.e. :

$$s_1 = 0{,}875\,\frac{\omega_1\,t_1}{2}$$

$$\leq 0{,}875\,\frac{0{,}0234 \cdot 0{,}047}{2} = 0{,}00047 \text{ m.}$$

This displacement is so slight that we shall neglect it in course of the calculation; we may even neglect the energy of rotation

$\frac{J'\,\omega_1^2}{2}$ which is very small.

For the period of the ensuing movement in course of which the chassis suffers a deformation which has the effect of exhausting the elastic force of all the buffers, it is also necessary to take into account the elastic force of the two chassis by doubling them, as was done with the buffer springs; in order to compensate for the elastic force of the suspension springs, the guard plates,

etc., by giving them the value 4 A_4. The remaining buffer energy is then :

$$A_p - 8 \cdot 450 - 4\ A_4 = 7\,980$$
$$- 3\,600 - 1\,824 = 2\,556 \text{ kgm},$$

and under the same conditions as above :

$$v'_1 = \frac{v}{2} \pm \sqrt{\frac{A_p - 8 \cdot 450 - 4\,A_4}{m} - \frac{v^2}{4}}$$

Since the value under the radical becomes negative, the elastic force of the frames is not completely utilised ; the shock period is already finished, since $v'_1 = v'_2$. In this case, therefore, it is necessary for :

$$A_p - 8 \cdot 450 - 4\,A_5 = \frac{m \cdot v^2}{4} = \frac{A_p}{2},$$
$$7\,980 - 3\,600 - 4\ A_5 = 3\,990,$$
$$4\ A_5 = 390, \text{ thus } A_5 = 97{,}5 \text{ kgm},$$

A_5 being the elastic force required by a chassis in the present case, on the supposition of a unilateral deformation.

For the truck loaded with goods in bulk, with a gross weight of 32 000 kg and a mass :

$$m = 3\,262\ \frac{\text{kg sec}^2}{m},$$

we get for a speed of collision of $v = 4$ m/sec: 14.4 km/h:

$$A_p = \frac{m \cdot v^2}{2} = \frac{3\,262 \cdot 16}{2} = 26\,100 \text{ kgm},$$

and

$$v_1 = \frac{v}{2} \pm \sqrt{\frac{A_p - 2\,A}{m} - \frac{v^2}{4}}$$

$$= 2 \pm \sqrt{\frac{26\,100 - 2\,768}{3\,262} - 4}$$

$$= 2 \pm \sqrt{3{,}15}$$

$$v_1 = 3{,}78 \text{ m/sec, and } v_2 = 0{,}22 \text{ m/sec.}$$

In addition for the second shock period, from the above calculation :

$$v'_1 = 3{,}53 \text{ m/sec, and } v'_2 = 0{,}47 \text{ m/sec.}$$

In order that there shall not be any plastic deformation during this shock period, it is necessary to determine the elastic power A_5 required, starting with the premises $v'_1 = v'_2$, i.e. the value under the radical is cancelled out and consequently :

$$\frac{A_p - 8 \cdot 450 - 4\,A_5}{m} - \frac{v^2}{4} = 0$$

$$\frac{26\,100 - 8 \cdot 450 - 4\,A_5}{3\,262} - 4 = 0,$$

$$A_5 = 2\,363 \text{ kgm.}$$

But as the chassis can only absorb 456 kgm elastically, there remains 2 363 — 456 = 1 907 kgm, unless the speed v is reduced.

We would then get :

$$\frac{\frac{m\ v^2}{2} - 8 \cdot 450 - 4 \cdot 456}{m} - \frac{v^2}{4} = 0,$$

whence

$$v = 2{,}6 \text{ m/sec, e. i. V} = 9{,}36 \text{ km/h.}$$

With ring springs, according to the same calculations, in the case of the loaded truck we get :

$$\frac{\frac{m\ v^2}{2} - 8 \cdot 1\,250 - 4 \cdot 456}{m} - \frac{v^2}{4} = 0,$$

$$v = 3{,}8 \text{ m/sec, i. e. V} = 13{,}68 \text{ km/h.}$$

The above example shows that in the case of an eccentric shock of collision likewise, the capacity of the buffer springs is the decisive factor, as the volute spring only allows of damping out a speed of collision of 9.36 km/h, compared with 13,68 km/h in the case of ring springs. If the shunting speed is too high, the fraction of energy in excess is damped out in both cases by an axial buffer shock which makes use of the elasticity of compression of the two side sills, which latter gives an appreciable amount of reserve strength, especially when hollow girders are used. To find

the best section for hollow side sills, the angles must be sharply rounded, as if the modulus of inertia of the two principal axes is slightly reduced, the stress due to the vertical and horizontal forces becomes more favourable.

It is also remarkable that in the case of a purely elastic stress, if the capacity of the chassis is to be fully utilised in the eccentric shock of collision, the speed of collision can be slightly greater.

The example calculated, with a single intermediate centre cross tie, represents a relatively simple case. It is possible to determine in the same fashion the corresponding values for several intermediate cross ties, taking care in this case that the elastic capacity of all the components affected by the shock are maintained as high as possible. The elastic power of the chassis also increases with the volume of the stressed beams. This power can be still further increased by giving these cross ties as far as possible equal strength by using appropriate U sections instead of tubular girders.

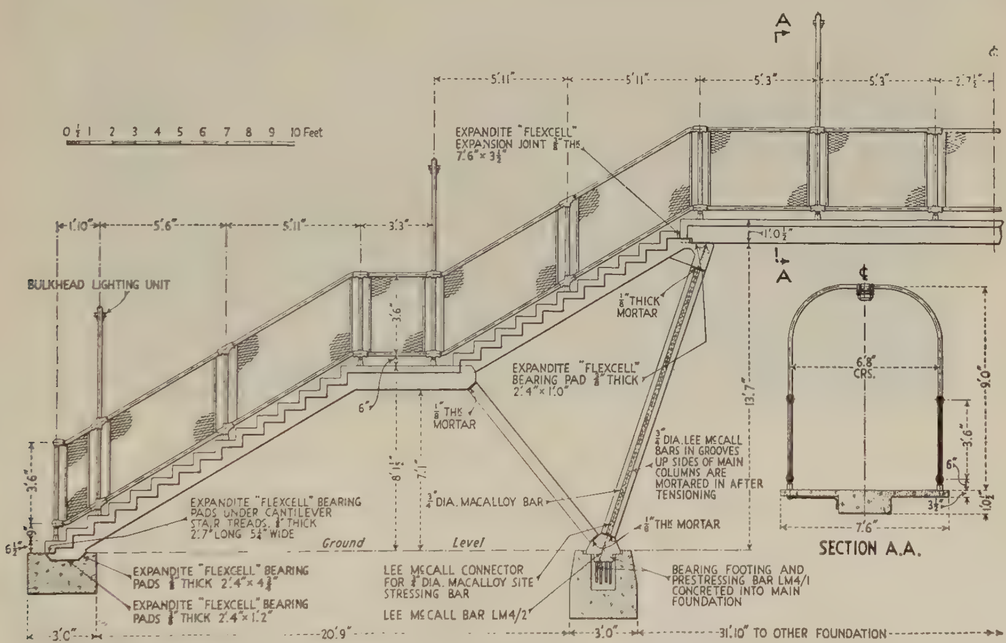
[625 .16 (42)]

Prefabricated footbridge at Bathgate Lower.

Moulded concrete slabs each supported on single pre-stressed concrete beam.

(*The Railway Gazette*, April 22, 1955.)

British Railways, Scottish Region, have replaced the former timber footbridge at the level crossing at Bathgate Lower Station by a structure of prefabricated concrete units.



Method of construction of stair flights, with section of central span.

The new bridge, which is 86 ft. in overall length, rests on four small concrete foundations. The five main units consist of concrete slabs 7 ft. 6 in. wide by 3 1/2 in. thick moulded to form stairs, landings, and main span. Each slab is supported on one pre-stressed concrete beam 2 ft. 4 in. wide and 9 in. deep.

Most of the weight of the bridge is taken on two main columns and two raking struts. The column and strut at each end of the bridge come together at their bases and are pivoted on two small concrete bearings measuring 2 ft. 4 in. by 1 ft. 6 in., which rest on two concrete foundations. The other two foundations support the lower ends of the first stair units. The parapet hand-railing and arch-type standards for the overhead electric lights are of tubular steel with expanded metal panels.

In the first stair flight, the central beam, 2 ft. 4 in. wide and 9 in. deep, supports the dead weight of the staircase and

landing, with an allowance of 110 lb. per sq. ft. to cover live load and snow. The beam under the stairs is pre-stressed with two 7/8-in. dia. and two 3/4-in. dia. Lee McCall bars, while the landing is reinforced with five 1-in. dia. mild steel bars bonded into the end of the pre-stressed beam.

The stair beam was cast first and pre-stressed, then elevated into its correct attitude and the remaining cranked portion together with the staircase and landing and then the slab was cast on top. The unit weighs 8 tons.

The struts and main columns are of normal reinforced concrete construction. The struts are 6 in. square in each leg and the columns 8 in. square. Steel dowels 1/2 in. dia. and 2 in. long are cast in both ends of each unit and these fit into steel tubes 5/8 in. dia. cast into the stair flight units and the bearing footings so as to locate the units during erection.

View showing general effect of slenderness in construction.

slab cast on in one operation. The weight of the first flight unit is 6 tons.

The second stair flight is designed and cast as for the staircase of the first stair flight, and the beam is pre-stressed with two 3/4-in. dia. Lee McCall bars. There is a heavily reinforced dovetail type of joint between this unit and the landing of the first stair flight. The unit weighs 3 ¾ tons.

The central beam of the main span, 2 ft. 4 in. wide and 9 in. thick, is designed to act compositely with the 3 ½-in. thick and 7-ft. 6-in. wide top slab. The loading is as for the staircase units. The beam, 27 ft. long, was cast first and pre-stressed with four 7/8-in. dia. Lee McCall bars,

The first stair flights sit on unreinforced slab footings cast with a shallow recess into which fit the heels of the central beams. The two main foundations which support most of the weight of the bridge were cast as reinforced slabs with central pockets into which were later concreted precast bearing footings which could be accurately levelled and positioned.

Because of certain possible mineral workings in the area, ground pressures were limited to 3/4 ton per sq. ft. max. under overturning moment, while normal direct loading (bridge fully loaded) gave just over 1/2 ton per sq. ft.

Longitudinaly, the bridge is stable because of its triangulated framing. Later-

ally it is subjected to wind pressure and eccentric live loading. Wind pressure is taken at 50 lb. per sq. ft. acting on the projected area of the bridge and at the same time half the bridge is assumed fully loaded on the leeward side with 110 lb. per sq. ft.

U-shaped high-tensile bars of 3/4 in. dia. were cast into the foundations so as to project about 6 in. from the bearing faces of the footings. After assembly of the main columns and second stair flights, 3/4 in. dia. high-tensile Lee McCall rods were run up grooves in the sides of the columns and through holes provided in the second stair flights. There were then coupled to the projecting ends of the U bars and tensioned to a load of 14 tons each, thus prestressing the columns and making them cantilever from the foundations to provide the necessary stability.

All the pre-stressed units were designed fully pre-stressed; that is to say, there is little or no tension under working load. In addition, the maximum factor of safety for ultimate moment is in excess of 2 for steel failure, taking combined normal dead load plus live load as unity.

Strength of materials.

The concrete used in the pre-stressed beams had minimum cube strength in excess of 7 500 lb. per sq. in. at 28 days and that used in the reinforced stairs and slab a minimum cube strength in excess of 6 000 lb. sq. in. at 28 days.

The 7/8 in. dia. and the 3/4 in. dia. high-tensile bars used in pre-stressing the units were tensioned to produce working loads of 21 tons and 15 ½ tons respectively.

The footbridge is to the design of the Chief Civil Engineer, Scottish Region, who also carried out the site work and erection. L. K. MacKenzie & Partners Limited, Glasgow, were responsible for the casting of the concrete units, in which the Lee McCall pre-stressing system was used throughout. The parapet handrailing and standands were supplied by the Expanded Metal Co. Ltd.

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HUBER (E.W.). — La **réforme du droit de transpo des voyageurs et des bagages** telle qu'elle résulte, e trafic international, de la Convention international (C I V) du 25 octobre 1952. (12 000 mots.)

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Les **Chemins de fer en 1953** (Suède). (2 000 mo & tableaux.)

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Les **résultats d'exploitation** des Chemins de fer fédé raux autrichiens en 1954. (1 000 mots.)

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MACHEFERT-TASSIN (Y.). — Les **locomotives à** **dresseurs ignitrons** de la Société Nationale des Chemins fer français. (4 500 mots & fig.)

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Le calcul des batardeaux cellulaires fondés sur rocher. 700 mots & fig.)

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JAEGER. — **La trempe superficielle haute fréquence appliquée à l'entretien du matériel ferroviaire.** (3 500 mots & fig.)

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DUGAS (R.). — Le **plan d'équipement** des Chemins de fer Britanniques. (1 600 mots.)

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La **coordination** « **rail-route** » à l'étranger. (1 700 mots.)

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LAPLAICHE. — **En marge du record du monde des 28 et 29 mars 1955. La question du freinage.** (800 mots & fig.)

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LEPINE (P.). — Le **jeu des horaires et ses combinaisons.** (2 000 mots & fig.)

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BÈGUE (A.). — Les **Chemins de fer Danois.** Etape à Copenhague. (1 500 mots & fig.)

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TASCHINGER (O.). — **Über die Sicherheit, die schnellfahrende Motor-Schienenfahrzeuge in Leichtbauweise bieten.** (6 000 Wörter & Abb.)

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FÜLLING (F.). — Ausschaltung und Aufgabenminderung von **Rangierbahnhöfen** an Hand von Beispielen. (2 200 Wörter & Abb.)

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KLATT (H.). — **Geschäftsbedingungen und Geschäftsgebräuche im Reisebürogewerbe.** (4 000 Wörter.)

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ZIMMERMANN (R.). — **Weichen mit Zungenüberschneidung als Bogenweichen.** (2 000 Wörter & Abb.)

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FRITZ (Ed.). — **Klimaanlagen für Eisenbahnwagen.** (3 000 Wörter & Abb.)

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HERBIG (A.). — **Schienenbefestigungen auf Beton oder anderen massiven Unterlagen.** (900 Wörter & Abb.)

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CONRADI (H.). — Das **Empfangsgebäude** des neuen Hauptbahnhofs in Heidelberg. (5 000 Wörter, Tafeln & Abb.)

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1955 **621** .33 (43)
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KOTZOTT (K.). — **50 Jahre Einphasenwechselstrombetrieb mit 25 Hz und 6 300 V** auf der Hamburg-Altonaer Stadt- und Vorortbahn. (5 000 Wörter & Abb.)

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SCHENK (O.). — **Tatzrollenlager an Fahrmotoren** elektrischer Triebfahrzeuge. (3 000 Wörter & Abb.)

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LEONHARD (E.). — Die **Entwicklung der Blinklichtanlagen.** (3 500 Wörter & Abb.)

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SCHMIDT (W.). — Das **Einstellen der Lichtsignale.** (4 000 Wörter & Abb.)

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ABBOTT (R.A.S.). — **Vertical boiler locomotives No. 1** *(to be continued)*. (2 800 words & figs.)

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LYNES (L.). — **Stressed wagon underframes** *(to be continued).* (3 600 words & figs.)

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They're built to maintain zero. (2 000 words & figs.)

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RUSSELL (R.B.). — **In this five-track bridge... superstructure is all welded.** (2 000 words & figs.)

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New plant to produce result of research : X-2 wheels. (2 600 words & figs.)

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New speed record set up in France. (600 words & figs.)

1955 **625** .13 (42)
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CROFT (E.H.). — **The mechanical design of bogie electric locomotives.** (2 000 words & figs.)

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1955 **656** .25 (493)
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Relay interlocking on Luxemburg Railways. (1 300 words & figs.)

1955 **625** .144 (42) & **625** .172 (42)
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Improved weedkiller train for British Railways. (1 400 words & figs.)

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In Danish (= 439.81).

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Los **Ferrocarriles en el Istmo Centroamericano.** (5 000 palabras & mapa.)

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FORN (R.). — El **acoplamiento hidráulico** y su aplicación a un tipo de locomotoras de gran utilidad en España. (3 000 palabras & fig.)

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HAMACHER (F.W.). — Tendencias relativas a los **coches-camas** en Alemania. (4 000 palabras & fig.)

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MARTINEZ RAYON (J.). & GUIDO GEYMAYR. — Los **hormigones con productos quimicos de adición, en las obras.** (2 000 palabras & fig.)

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SANTORO (F.). — Sul **servizio combinato ferroviario-automobilistico.** (4 000 parole.)

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FIORENTINI (A.). — Un **nuovo treno stradale adatto per sottovie** (subways urbane). (4 000 parole & fig.)

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BELLONE (S.). — **Teleferiche per trasporto materiali. Le stazioni.** (5 000 parole & fig.)

1955 **721** .9
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GAZZANO (G.). — **Tavola generale per strutture inflesse in cemento armato.** (1 500 parole & tavole.)

In Netherlands.

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1955 **625** .42 (492)
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VAN WITSEN. — De mogelijkheid van **ondergronds vervoer** in Amsterdam. (3 000 woorden & fig.)

1955 **624** .2
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NOZ (F.J.). — Het **ontwerpen en controleeren van cirkelvormige gewapend-betondoorsneden.** (6 000 woorden & fig.)

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1955 **656** .212 .5
Spoor- en Tramwegen, nr 10, 12 Mei, p. 148.
PENTINGA (K.J.). — **Heen en weer heuvelen.** (1 200 woorden & fig.)

1955 **385**
Spoor- en Tramwegen, nr 11, 26 Mei, p. 161.
De **Toekomst der Spoorwegen.** (2 000 woorden.)

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VAN WIJCK JURRIAANSE (N.J.). — **De diesel-electrische locomotieven der serie N.S. 2400.** (2 000 woorden & fig.)

1955 **656** .254 (44)
Spoor- en Tramwegen, nr 11, 26 Mei, p. 168.
NYMEYER (A.G.). — **Draadloze besturing van een trein** bij de S.N.C.F. (1 000 woorden & fig.)

In Swedish (= 439.71).

Järnvägs-teknik. (Statsbaneingenjören). (Stockholm.)

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LIEDGREN (Sven). — **Macadamized ballast** — some points of view. (2 400 words.)

1955 **526** .918 : **656** .21 (485) = **439** .71
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ALLAN (B.). — **Aerial photography of stations.** (700 words & fig.)

1955 **625** .142 .2 = **439** .71
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RENNERFELT (E.) & NYBERG (J.). — **Reimpregnation of sleepers.** (2 600 words & fig.)

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MEINSTAD (T.). — Experience of **centralised traffic control** on the Netherlands Railways. (2 400 words.)

1954 **656** .211 .5 (73) = **439** .71
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EKELUND (A.). — **Orders of tickets by phone.** An experiment on the Southern Pacific. (1 700 words & fig.)

1954 **624** .1 = **439** .81
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GODSKESEN (O.). — **Formulae for pile-driving.** (500 words.)

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SKAVEN-HAUG (Sv.). — **Preventing deformation by frost on the Norwegian State Railways.** (2 300 words & fig.)

1954 **625** .12 (480) = **439** .71
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